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# ***JPRS Report***

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## **China**

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### ***SCIENCE AND TECHNOLOGY***

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# Science & Technology CHINA

JPRS-CST-89-025

## CONTENTS

17 November 1989

### SCIENCE & TECHNOLOGY POLICY

Developmental Strategy of the 'Spark Plan' and the Larger International Picture [Wan Junkang, Li Qunxing, et al.; KEYAN GUANLI, May 89] .....	1
Increased Role of CAS in Advancing Absorption of Imported Technology [Fang Zhansheng; KEYAN GUANLI, May 89] .....	5

### AEROSPACE

FY-1 Meteorological Satellite [Meng Zhizhong, He Zhenghua; YUHANG XUEBAO, No 3, Jul 89] .....	8
Sponge Model for Aluminum Agglomeration in Solid Composite Propellants [Jin Leji, Li Shufen; YUHANG XUEBAO, No 3, Jul 89] .....	8
Improving Time Suboptimal Control [Wang Zicai, Zhao Jianhua, et al.; YUHANG XUEBAO, No 3, Jul 89] .....	9
Influence of Protuberances of Missile Body on Missile Aerodynamic Characteristics [Wan Yin; YUHANG XUEBAO, No 3, Jul 89] .....	9
Transition-Induced Normal Force, Its Effects on Slender Sharp Cone Aerodynamics [Lou Hongtian; YUHANG XUEBAO, No 3, Jul 89] .....	9
Study of Acute Hypoxic Effect on Human Performance Under Aerospace Conditions [Zhang Jingxue, et al.; YUHANG XUEBAO, No 3, Jul 89] .....	10
Synthesis of Silicon Carbide Fiber Using Blend of Polycarbosilane, Hydroxy-Terminated-Polybutadiene As Precursor [Yang Yiming, Yang Shujin, et al.; YUHANG XUEBAO, No 3, Jul 89] .....	10

### BIOTECHNOLOGY

New Reagent for Screening AIDS Virus [GUANGMING RIBAO, 15 Aug 89] .....	11
Cloning and Expressing of Bacillus thuringiensis subsp. galleriae (H5ab) $\delta$ -Endotoxin Gene [Chen Qi, Fan Yunliu; ZHONGGUO KEXUE [SERIES B], Jul 89] .....	11
Studies on Structure and Synthesis of Arteannuin and Related Compounds [Zhou Weishan, Huang Dazhong, et al; HUAXUE XUEBAO, Jul 89] .....	11
CW Agent First Aid Kit Developed [KEJI RIBAO, 14 Sep 89] .....	13
The Transgenic Fish Expressing Human Growth Hormone Bred [GUANGMING RIBAO, 29 Aug 89] ...	13
Transferred Rice Plant Carrying Insecticidal Gene Produced [GUANGMING RIBAO, 29 Aug 89] .....	13

### COMPUTERS

More Reports on, Analyses of Computer Viruses .....	14
Some Network and Other Computer Viruses [Du Weiping; JISUANJI KEXUE, No 3, 23 Jun 89] .....	14
Virus Infection Spurs Calls for Copyrights [Jiang Guozhong and Xiao Zhong; DIANZI SHICHANG, 14 Aug 89] .....	16
More on the Bouncing Ball Virus [Jiang Wangzhong and Bei Yan; DIANZI SHICHANG, 14 Aug 89] .....	16

### FACTORY AUTOMATION, ROBOTICS

Technical Transformation of Machinery Plants Toward Computer Integrated Manufacturing Systems [Li Kaifo; JICHUANG, No 6, Jun 89] .....	18
Key Technical Points of Iron-Making in 1989 Reviewed [Xu Juliang; GANGTIE, May 89] .....	24

### MICROELECTRONICS

New Method for Achieving Sub-Micron Line Widths Described [Xie Kexun, Jiang Jianfei, et al.; BANDAO TI XUEBAO, No 7, Jul 89] .....	27
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Electrical Properties of S <sup>+</sup> -Implanted SI GaAs [Xia Guanqun, Guan Anmin, et al.; BANDAOTI XUEBAO, No 7, Jul 89] .....	28
Photoluminescence of Heavily Doped GaAs:Si, GaAs:Be Grown by MBE [Hu Tiandou, Hu Jizong, et al.; BANDAOTI XUEBAO, Aug 89] .....	31
Comparison Between Photoreflectance, Electroreflectance of GaAs-Electrolyte Interface by Means of Direct Observation of Voltage Waveform Across Surface Barrier [Cao Xiafen, Zhao Dong, et al.; BANDAOTI XUEBAO, Aug 89] .....	32
Investigation of Lattice Mismatch of MBE In <sub>x</sub> Ga <sub>1-x</sub> As/GaAs(001) System [Wang Yutian, Li Chengji, et al.; BANDAOTI XUEBAO, Aug 89] .....	32

## Developmental Strategy of the 'Spark Plan' and the Larger International Picture

40080220a Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 3, May 1989 pp 17-21

[Article by Wan Junkang [8001 0689 1660], Li Qunxing [2621 5028 2502], Fang Guoqiang [2455 0948 1730], Hu Shuhua [5170 2885 5478] and Liu Guoxin [0491 0948 2450] of the topic group of the Science Commission of Hubei: "Development Strategy of the "Spark Plan" in the Large International Economic Cycle - Opportunities, Challenges and Development Models"]

### [Text] Abstract

Various opportunities and challenges facing the implementation of the "Spark Plan" are analyzed based on changes in the international economic environment. New objectives and tasks of the "Big Spark Plan," such as economies of scale and proper role playing, are presented. The basic strategy of combining foreign and domestic markets to form a dual-track cycle and a regional and product step development model are introduced.

### I. Opportunities, Challenges and Mission

#### (A) Seize the Opportunities

Since the "Spark Plan" was implemented 2 years ago, we have made very rapid progress; this fully demonstrates the validity of the basic policy—vitalizing rural economy by science and technology. Since the implementation of the consolidated rural contract responsibility system, agricultural productivity has been liberated, resulting in the mushrooming of local businesses. Agriculture has been commercialized. Farmers have a very strong demand for science and technology. The central government decided to take advantage of this opportunity to implement the "Spark Plan," which provided a great deal of vitality to the program.

However, it would be inadequate to limit ourselves to domestic opportunities alone. There is a growing trend to have an integrated world economy. Economically, every country is mutually dependent and constraining on each other. Dynamic changes of labor distribution in the world caused by development of productivity and advances in science and technology often offer excellent opportunities to countries that are developing their own economy. Therefore, in view of the fact that the "Spark Plan" is in a developing stage, we must reassess the situation and provide a comprehensive analysis due to changes around the world. We must be fully aware of current economic changes and take advantage of the new opportunities presented to us as a result of the "coastal strategy" in order to lead all kinds of industries into the international cycle.

First, due to the reorganization of the international industrial structure, economic and market voids are

created, providing an opportunity to allow the "Spark Plan" to participate in the international economic cycle. The new technology revolution prompted a major reorganization of the worldwide industrial structure. Developed nations are competing to develop high technology and build new industry. A series of new technologies and a cluster of industries has been established. The industrial structure is pushed upward and knowledge is being concentrated. Some newly industrialized countries (NICS) and areas are making a transition from a labor-intensive structure to a capital- and technological-intensive structure. The transition to a labor-intensive structure is focussing on southeast Asia and China. Thus, a new industrial structure ladder and chain is formed as shown below:

Bottom step: labor-intensive type; developing nations, NICS, developing nations

Middle step: capital-technology-intensive type

Top step: high-technology, knowledge-intensive type

The current industrial structure in China is primarily the labor-intensive type. From the world perspective, the labor-intensive structure will exist for a long time in history. The re-organization of the international industrial structure created some voids for the export of labor-intensive products and capital-knowledge-intensive products from China. Thus, it offers an excellent opportunity for the "Spark Plan" to utilize worldwide resources to enter both domestic and foreign markets.

Second, the active investment climate in the world provides an opportunity for the "Spark Plan" to attract foreign capital. In the past decade, international investment has become the driving force behind worldwide economic growth. Some developed nations have accumulated excessive amounts of capital and are eager to expand the flow of capital out of the country. This helps the export of their products and technology in order to win more market share and achieve further expansion. NICS and some developing nations, in order to stimulate their own economy and establish a new international order, are also playing an active role in exporting capital to other countries. The transnational corporation becomes the basic mode for direct foreign investment. Based on statistics, by late 1970, nearly 80 state-owned businesses had made direct investments in 150 nations, established 12,000 parent corporations and 100,000 subsidiaries. The total investment is approximately \$400 billion. China has a serious shortage of capital and must utilize foreign capital to alleviate problems associated with the shortage of funds. Due to lack of funds, the government cannot afford to invest a large sum of money in the "Spark Plan." We must attract foreign investment by taking advantage of the fact that the advanced technology involved in the "Spark Plan" is short-term, stable and rapidly achievable. A single spark can start a prairie fire. This is an important strategy to enhance our competitiveness in the world.

Third, the regional trade patterns and international financial trends are also favorable for the "Spark Plan" to penetrate the international market. One-third of world trade volume takes place in the Asia and Pacific region. The rise of the region projects that the focus of world trade will shift from the Atlantic to the Pacific. Thus, Chinese products will have an obvious geological advantage in the international market. In addition, the appreciation of Japanese, Taiwanese and Hong Kong currencies have raised the labor cost in these countries and areas. This will give us an edge in exporting labor-intensive products.

Fourth, the implementation of the "coastal region strategy" put the "Spark Plan" on the track of providing economic services to the outside world. Moreover, it also leaves enough room for the "Spark Plan" to work in the domestic market.

### (B) Meet the Challenges

Opportunities for economic growth and challenges often come together. The Thirteenth Party Congress report pointed out that "In view of rapid technological transformation, increased market competition, and the ever-changeable international political situation, we are facing urgent and severe challenges." This is also the challenging environment that the "Spark Plan" is facing. Specifically,

#### 1. Challenge From Technical Advances

Our local industries are essentially the "traditional" labor-intensive type. Although cheap labor is to their favor, it is difficult for them to greet new technological advances due to weaknesses such as obsolete equipment, outdated technology, low efficiency, poor quality and environmental pollution. There is an urgent need to make the transition from the traditional labor-intensive type to the modern labor-intensive model through technological transformation. The basic symbol of the modern labor-intensive model is to rely on technical advances to develop products, to be guided by technology rather than resources, to become intensive instead of extensive, to adopt scientific management and modern manufacturing rather than following bad customs and habits, to treasure talents instead of wasting manpower, and to protect the environment rather than destroying the ecology. This is also the production technology standard to be met by the "Spark Plan." In order to further improve the technical quality of the "Spark Plan" in an accelerated manner, new seeds will have to be continuously injected to meet the challenges of technological revolution.

#### 2. Challenges From Increased Competition

Although the "Spark Plan" has included a number of internationally competitive products, the participating industries focussed more on pressure from domestic competition and less on the international market situation. Once we enter the international economic arena and participate in labor division and competition, the

level of competition will be increased from the less competitive domestic market to the highly competitive international market. We will be competing with manufacturers and enterprises from NICS and developed nations in the international market. Whether we have the courage, resourcefulness, strategy and capability is the premise to determine whether we can meet the challenge of increased competition. This is a weak spot in the "Spark Plan" which makes it difficult to enter the world market.

#### 3. Challenges From Industrial Reorganization

Industries are both highly concentrated and scattered in the modern commodity economy. On one hand, the means of production are concentrated in a few enterprises (groups). On the other hand, the means of production are scattered among a large number of small businesses. They are mutually dependent upon each other and complementing each other in a highly specialized cooperating network. Regardless of the form, capital always flows from low-productivity areas to high-productivity areas. It concentrates in the hands of businessmen with high-technology and good management skills. This causes frequent failures, mergers and reorganizations among businesses. This situation is especially common in developed nations and has happened in China. Thus, the "Spark Plan" is being challenged by industrial reorganization because it was originally designed that each individual company would make things work by itself, and the plan would use it as a model for others to follow suit. In addition, we have to choose the correct strategy to create broad economies of scale and to develop leading products in order to achieve horizontal integration.

In conclusion, the opportunities and challenges for the "Spark Plan" to participate in the larger international economic cycle are present simultaneously. There has to be some feeling of urgency and crisis. First, we have a number of favorable conditions, including an abundance of low-cost labor and a variety of accessible natural resources. With sound management, the advantage of low cost is unbeatable. Next, it is easier to turn the boat around if it is small. Once we combine science and technology with the flexible structure of local businesses, they can be rapidly transformed into a great deal of productivity. Last, in the "Spark Plan" all the research institutions are behind us. This allows a number of enterprising people of the "Lu Guangqiao" type to surface. A large number of outstanding technical people are forming an active management team in the domestic market. They have preliminarily established some focus areas and groups for the "Spark Plan" which will serve as models. In view of the new situation, the "Spark Plan" must take advantage of its positive aspects to offset its shortcomings in order to turn all unfavorable factors around. In addition, we have to re-adjust the development pattern.

### (C) Goals and Mission

The goals and mission of any task are determined by its intrinsic characteristics. In other countries, they are scientifically analyzed with the "6W" method; i.e., What, Why, Who, Where, When and How. Based on this logic, we believe it is necessary to perfect or develop the concept and domain of the original "Spark Plan" in order to provide new contents to ascertain the new goals and mission.

#### 1. The "Big Spark Plan"

The "Spark Plan" was formulated to vitalize rural economy with science and technology. The implementation of any science-and-technology-related plan or project that promotes the transformation of the rural labor force and speeds up the industrialization, commercialization and modernization of agriculture should be considered as a part of the "spark" which transplants the gene of civilization to the rural area. This is the concept of the "Big Spark Plan." In reality, the government-supported "Spark Plan" is only a small portion of the gigantic goal of starting a prairie fire. The goal can only be accomplished by spreading the spirit of the "Spark Plan" around the world, breaking the barriers between departments, and consolidating all "Spark Plan" projects that are now under the jurisdiction of different levels of science and technology commissions with those projects supported by the people, entities, individuals and foreign investments which meet the definition of the "Spark Plan." Different levels of management of the "Spark Plan" should not be limited to the review and inspection of the projects within their jurisdiction. Instead, under the guidance of the government, we should push the "Spark Plan" to a new breadth and depth through cooperation and utilization of all favorable factors.

#### 2. Economies of Scale

The "Spark Plan" stresses the demonstration of concept. A good example can cause the success of many to cover the entire country. However, it must be based on economies of scale to use a point as a convincing example. Here, economies of scale have two levels of meaning. One is to create the lowest-cost large-scale production capacity that meets market demand through a rational combination of production factors within the business. The other is to develop various kinds of joint ventures to create the "Spark Groups" and "Spark Concentrated Areas" as described by the concept of the "Big Spark Plan." The "Spark Concentrated Areas" are then gradually developed into a special technology-intensive economic zone to be used as a model for rural industries to develop to meet outside needs. We should integrate projects within the "Spark Plan" with other projects either in the plan or not in the plan at various levels through technical cooperation or joint efforts in order to draw on the strength of each to offset the weakness of the other. Compared to the success of an individual business, this not only is a more convincing model but also

can improve the overall technical development capability and management level of the "Spark Plan." This strengthens its thrust and ability to develop a rural commodity economy and enhances our strength to join the international economic circle. We believe these two meanings are mutually complementary. It can free the "Spark Plan" from "isolation" and allows a business to strengthen its internal management and to face both the domestic and foreign markets.

#### 3. Playing Both Leading and Supporting Roles Well

Since the new economic structure leaves room for the "Spark Plan" to develop, it is required that the "sparks" spread around the country find their own correct positions. Each "Spark Plan" project not only may be in only a certain industry but also only at a certain quality level. The strength of the partners and competitors in the commodity economy also varies. Therefore, the "Spark Plan" may play a leading role or supporting role in the domestic or international market. Generally, the "sparks" are mostly in supporting roles in the presence of enterprises led by large key industries or trading groups specializing in export. In this case, the important thing to do is to use all strengths to cooperate. We should depend on the strength and technology of the group to survive and grow. In case there is a distinctive advantage in resources, labor or management, a "spark" may pick up the leading role to form economies of scale by integrating technology, trade, industry and agriculture. The most important factors are the quality, courage and resourcefulness of the businessmen and the selection of product and market strategy.

### II. Selection of Strategy for the "Spark Plan"

The nature of a strategy is to make a scientific projection of the direction, goal and approach for the future in order to stay on the active side. In view of the new situation, we suggest that we focus our thoughts in the following areas as we try to determine the strategy for the "Spark Plan."

#### (A) The Dual-track Basic Strategy of Combining Domestic and Foreign Markets

We have to break away from the traditional thinking limiting us to the domestic market when we implement the "Spark Plan." We must develop a service economy for the outside world. However, we cannot isolate the domestic market from the foreign market. Only when the domestic economy is circulating unimpededly can we participate in the international circle. Therefore, the strategy of "combining domestic and foreign markets to create a dual-track cycle" is as follows:

1. Let us focus on labor-intensive products first and gradually increase the proportion of technology-intensive products for both domestic and foreign markets. On one hand, we can fill the voids left behind due to industrial reorganization and implementation of the coastal strategy to meet domestic market demands and to bring prosperity to local areas. On the other hand, we

will enter the international market under the guidance of the plan in a step-by-step manner. The import/export structure will experience dynamic changes based on a comparative benefit principle. The entire national economy will be vitalized by directing exports and finding substitutes to imports.

2. Let us combine imports and exports and form a dual-track circle to use exports to pay for imports and to use imports to stimulate exports. To join the international circle is an objective requirement for integration of the world economy; however, it is not our goal. Instead, it is a means to modernize our economy which makes our country more powerful and our people more prosperous. As far as the "Spark Plan" is concerned, it facilitates the industrialization, commercialization and modernization of agriculture and urbanization of rural areas. To this end, we must implement this dual-track system.

(1) When both imports and exports are high, the imports must stimulate the exports to ensure more exports. Otherwise, it will be difficult to maintain the balance. However, we cannot give absolute priority to foreign trade. We cannot weaken the economic connection between inland and coastal areas. When it is more favorable to use inland resources, we should focus on exports or mostly on exports and only partially on imports (some raw materials will be supplied domestically).

(2) There are a variety of ways to achieve high volumes of exports and imports. For instance, we can import raw materials (and pay  $W_i$  in foreign exchange) and export products (and receive  $W_o$  in foreign exchange), provided  $W_i < W_o$ .

In conclusion, a dual-track circle will be formed regardless of the type. We must seriously study the feasibility and check out the accounting of such a cycle to ensure its smooth circulation. Only when the projected exports exceed projected imports will the government be able to increase its ability to pay in hard currency; a business can then afford to grow on its own strength, and a vital operation will be possible to promote the growth of China's economy.

#### (B) Regional and Product Step Development Model

China is a huge country and the local economy varies greatly. In the countryside it is particularly imbalanced. Prosperity and poverty and advanced and outdated technology co-exist. Therefore, after we have adopted the dual-track cycle strategy for the "Spark Plan," we must formulate an overall plan to progress in steps. Specifically, we are required to control the regional and product step development strategy.

##### 1. Regional Step Development Strategy

We can divide the area under the "Spark Plan" into developed, relatively developed, and underdeveloped regions. For example, in regions such as the Chang Jiang

Delta, the Zhu Jiang Delta, the Golden Triangle in southern Fujian, and the Liaodong Peninsula, local businesses are active and a commodity economy and science and technology are relatively developed. Along the Chang Jiang and the railroad between Beijing and Guangzhou the economy is relatively developed since there is some technology base and some resources. In remote areas and mountain regions where transportation is still a problem the economy is yet to be developed. The three regions are not divided purely by geographic location. Instead, the major criteria include important factors such as technical equipment, management level, labor quality, transportation, economic cooperation, and the ratio of the value of exports to the total gross product in the local area.

In the developed region, the "Spark Plan" should establish a mechanism to direct exports, develop projects for exports and organize to join the big international circle. These regions are in good geographic locations and provide easy transportation to other countries. In addition, they have high technical quality and a good economic environment which are favorable factors for the implementation of the export guidance strategy. In relatively developed regions, a selective export-substitution plan may be adopted to import technology with the capital accumulated from foreign trade; this technology will be used to develop and manufacture products that have previously been imported or are in demand. Thus, we not only expand the domestic market by filling voids but also push forward in technology. In underdeveloped regions, we should stay with the strategy which draws on strengths to offset weaknesses and takes full advantage of local resources and special handicrafts to produce products in short supply. While dominating the local market, we should gradually penetrate the domestic and international markets. Although these three regions have their own strategy, they are mixed and mingled to form a regional step development strategy. Each "Spark Plan" item is not isolated. Under the guidance of this strategy, we can establish a flexible network to link points for export or to form a cluster domestically. To link points for export means we will link export-product-based businesses in developed, relatively developed and underdeveloped regions to create a consolidated entity consisting of trade, technology, industry and agriculture. To form domestic clusters means we will form groups based on technology aiming at profits.

##### 2. Product Step Development Strategy

China has an abundance of resources. In the initial stage of the "Spark Plan" we do not have sufficient capital and strength. We will build a number of medium and small resource-intensive businesses to produce resource-intensive products. This will facilitate the utilization of scattered resources and local labor. It requires very little investment to produce low-cost products and takes very little time to see the results. However, because resources are limited and need to be comprehensively utilized, resource-intensive products cannot become the leading products in the "Spark Plan." Therefore, we should

continuously increase the level of processing. The "Spark Plan" should begin with labor-intensive products and the direction of transformation should be toward developing technology-intensive products. Most products in developed nations have gone through a transition from a lower level to a higher level. To develop high technology has become a worldwide trend. In addition to developing short-lead-time and low-risk projects, the "Spark Plan" also should import and develop some high technology and continue to improve the quality of labor-intensive products in order to march toward technology-intensive products.

The product step development strategy (which also reflects the need for stepwise development in industry and technology) and regional step development strategy are mutually compatible with each other.

The step development strategy of the "Spark Plan" is also closely connected to the strategy of opening both domestic and foreign markets.

#### **Increased Role of CAS in Advancing Absorption of Imported Technology**

40080220b Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 3, May 1989 pp 25-27

[Article by Fang Zhansheng [2455 1455 4141] of the Lanzhou Institute of Chemical Physics of the Chinese Academy of Sciences: "To Utilize the Advantages of the Chinese Academy of Science (CAS) to Push the Absorption and Digestion of Imported Technology to a Higher Level"]

#### **[Text] Abstract**

Based on the experience of CAS's involvement in the absorption and digestion of imported technology, it is proposed that the CAS should participate in this type of work in a timely manner as it enters the battlefield of economic construction. The CAS should fully utilize its advantages and work closely with production departments to advance the absorption and digestion of imported technology to a higher level to allow us to make additional progress and to be creative. In addition, several recommendations with regard to problems associated with the absorption and digestion of imported technology in China are presented.

Based on relevant statistics, in the decade between 1973 and 1982 China imported 279 technology-related items. The mechanical industry imported 206 items, which is 74 percent of the total. In addition, it also imported 448 pieces of equipment. This stage of imports focussed on applied technology, mostly in the form of imported equipment, complete sets of equipment and production lines. In the 1980's China's industrial level was improved and research force strengthened. This stage of technology imports was guided by the use of permits. For instance, among the 679 items imported in the Sixth 5-Year Plan, 74 percent of them were imported with

permits. It is obvious that the focus of technology imports has shifted from the easy to the difficult in the direction of design and manufacturing technology and research and development technology as the overall technical level improves in China.

The primary content of technology import is advanced foreign technology, know-how and experience. It includes different levels such as applied technology, design and manufacturing technology and research and development technology. In order to enhance China's ability to develop its products, strengthen its market competitiveness, increase exports of technology-intensive products, and truly join in the big international economic development circle, China should develop its own science and technology, promote the growth of its national economy and adopt a strategy to advance its technology to a higher level.

In order to accomplish this strategic objective, the CAS should participate in the absorption and digestion of technology imported by the government in a timely manner as it enters the main battlefield of economic construction. The CAS should utilize its advantages fully to push the absorption and digestion of imported technology to a higher level so that we can develop our own technology to make an important contribution to economic and technological growth in China.

In the past, due to the deep division imposed by the system, although CAS was only involved in a few projects related to the absorption and digestion of imported technology, they were nonetheless mostly successful. These successful cases not only made a contribution to the nation but also gave us some inspiration. The Changchun Institute of Applied Chemistry cooperated with the Xiamen Photographic Materials Corporation to absorb and digest imported raw materials to make Kodak color film. As a result, several raw materials are manufactured domestically and there have been new inventions. This has been a major contribution to the film industry in China and the impact is tremendous.

The Lanzhou Institute of Chemical Physics (LICP) in recent years has been involved in the absorption and digestion of imported technology. There are two typical projects which are inspirational. One is the absorption and digestion of a trace dehydrogenation catalyst used in urea production and the other is that of an energy-saving engine additive.

#### **I. Dehydrogenation Catalyst**

This is the catalyst used in the 520,000-ton-capacity urea production equipment imported as a complete set of technology. It was a part of the key national absorption and digestion project—a 300,000-ton-capacity synthetic ammonia and urea production project. Chemical engineering departments in Sichuan and Shanghai attempted to analyze and imitate the catalyst. Nevertheless, it never reached the same level as the import. Furthermore, it is more expensive than the import. LICP fully utilized its technical strength in catalyst research since it took over



this assignment and developed the DH-2 dehydrogenation catalyst. It was successfully tested in pilot runs and has replaced the imported catalyst. It was further tested in production for one year and found to meet all the technical specifications of the imported catalyst. Moreover, it costs less than one half of the import. It has been successfully certified jointly by the CAS and the China Petroleum Corporation and was specified as the substitute for the imported catalyst by the China Petroleum Corporation and the Ministry of Chemical Industry. It is used in large and medium urea production plants in China and will be used in urea production facilities built in the Seventh and Eighth 5-Year Plans. This project, due to the successful absorption and digestion, the benefits generated and the new level achieved, was given a first-class technical progress award by the CAS in 1988.

What made it a success? In general, it relied on the advantages of the CAS.

#### (I) Long-term accumulation of research results

The ordinary way to absorb and digest imported technology is to analyze and imitate. The result at best is to catch up and thus eliminate the gap. LICL successfully developed the dehydrogenation catalyst by designing and developing its own catalyst based on its thirty years of experience in catalyst research and by making reference to the characteristics and application requirements of the catalyst and by analyzing the imported catalyst. Since we knew it well, it was easy. The research was done quickly in the laboratory before entering the development and industrial test phase.

#### (II) Detailed research and strongly supported basic study

In addition to the 1,000-hour stability test in the laboratory, after taking the requirements for medium- and long-term use into consideration, the catalyst developed by LICL was tested on a pilot-plant basis in a medium and a large urea plant for 2,000 and 1,700 hours, respectively, in order to ascertain the composition, preparation method and reactive conditions of the catalyst before it was finally tested in production. After one full year of operation, the performance characteristics and specifications of the catalyst were fully evaluated and it has won the confidence of the plant. In addition, we also conducted some basic research. The preparation of the catalyst was guided by the findings from studies on catalytic adsorption, catalytic surface chemistry and surface physics, and catalyst deactivation mechanisms. A competitive adsorption mechanism is used to disperse the active material on the surface at a higher loading to improve the specific activity of the precious metal and to increase air speed. Consequently, the amount of precious metal used is reduced. The new catalyst developed uses only one half of the precious metal in the imported catalyst. Moreover, its carbon-monoxide resistance and low-temperature performance are better than those of the catalyst made in the United States. The product is in a position to compete in the international market to beat the monopoly held by the U.S. patent.

#### (III) The multi-disciplinary advantage

In the development of the dehydrogenation catalyst, we organized a joint effort involving catalysis and catalytic base, analytical chemistry and structural chemistry. We fully utilized the multi-disciplinary advantage to get twice the result with half the effort. The research level was also significantly raised.

#### II. Energy-Saving Additive

This is a widely used energy saver for automobile engines. It is not only convenient to use but also effective. We have imported a number of these products in large volume. Gansu Province, for example, had been importing energy-saving additives. The provincial planning commission assigned the task of analyzing and imitating the energy-saving additive to LICL and a local research institute. LICL organized a team to provide support in analytical chemistry and lubricant study. Based on its advantages in analyzing new materials and in developing lubricants, the institute completed the assignment in a little over 6 months. The LA-101 energy-saving additive was developed. Based on comparison tests performed on engines in the laboratory and in actual road tests, it meets the specifications of the original foreign product. It was certified and put in trial production for wide distribution. The speed and quality of development have exceeded those in the original plan and have surpassed the work done at other organizations.

During the process of imitating the energy-saving additive, after taking the availability of domestic resources and our urgent need into account, they developed the GRT-type energy-saving lubricant additive which contains a graphite gel; this development was based on the strength and technology they have accumulated in lubricant research. The additive was road-tested by the [PLA's] General Logistics Department for over 50,000 kilometers and was found to save approximately 7 percent of fuel and over one half of oil. It also reduces engine wear, lengthens its useful life and improves engine performance. Due to its better thermal stability, this additive is not corrosive to the machine and the graphite is non-toxic. Thus, this product is better than other products imitated or developed by other organizations in China. It is a world-class product and has been transferred to industry for production. In addition, the Institute and the New Materials Development Corporation also plan to invest in building a plant. The accumulation of research on the GRT energy-saving additive, especially the concurrent basic study in colloidal chemistry and lubrication chemistry, provided the basis for the research on the LA-101 additive. The progress was faster than that required by the provincial planning commission. The LA-101 additive uses domestic raw materials and costs far less than imported additives. Particularly, the formula developed from basic research makes it far less corrosive than the import. In the near future this domestically produced high-performance energy-saving additive will be widely available in the

marketplace to replace imported additives. It will also compete in the international market.

From these examples it is not difficult to see that the CAS can accomplish quite a great deal in the absorption and digestion of imported technology. As long as we fully utilize the advantages of the CAS and cooperate closely with manufacturers, it is possible to advance absorbed and digested imported technology to another level, allowing us to make breakthroughs and to be innovative.

To this end, we recommend that the government and relevant departments should:

1. Have an in-depth plan for importing technology, reinforcing tactical consciousness, and stressing the priority of imports for technical strength.

2. Strengthen control of the absorption and digestion of imported technology and adopt feasible measures to smash feudal separationist selfish behavior and to consider the well being of the state. Open bids should be solicited for all imported items and only the better ones should be selected for support.

3. Implement "reverse engineering" in the process of importing technology. China should independently select technologies and specimens to simultaneously conduct research, modification and innovation based on our needs. We will ask for multi-disciplinary and inter-industry cooperation and organize lateral joint efforts between the CAS and large and medium industries to accomplish the task of absorbing and digesting imported technology.

**FY-1 Meteorological Satellite**

40090001a Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 1-9

[English abstract of article by Meng Zhizhong [1322 1013 0022] and He Zhenghua [0149 2973 5478] of Shanghai Institute of Spacecraft Engineering]

[Text] The first Chinese experimental meteorological satellite FY-1 was launched on 7 September 1988. The main objectives of the FY-1 are: testing and examining the space technology used for this satellite and the ground manipulation as well as the application of this satellite.

This satellite's orbit is nearly circular, with an altitude of 900 km and inclination of 99 degrees. The period is 102 minutes. It rotates around the earth 14 times every day. The spacecraft was researched and developed in China independently and is composed of domestic materials and components. It comprises seven main subsystems: the power supply, thermal control, attitude control, scanning radiometer, cosmic ray monitor, picture transmission and TT&C. It weighs 750 kg. The main body measures 1.2 m x 1.4 m x 1.4 m, with deployable solar panels connected to the left and right sides. The length of the spacecraft is 8.6 m and its height is 1.76 m. The power subsystem has 6 panels covered with 14,256 silicon cells, each measuring 2 cm x 2 cm. The three-axis attitude control subsystem turns the satellite toward the earth during the attitude acquisition phase, then keeps the satellite pointing to the subpoint of the track. The visible and infrared scanning radiometer has five channels and presents an output signal with 1.1 km ground resolution of digital imagery on the subpoint and 4.0 km average resolution of analog imagery on the covered ground surface. The picture transmission subsystem comprises APT, HRPT and playback transmissions. High-quality pictures are received by the ground stations.

**Sponge Model for Aluminum Agglomeration in Solid Composite Propellants**

40090001b Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 25-32

[English abstract of article by Jin Leji [6855 2867 7535] of Red Star Chemical Institute of Hubei; Li Shufen [2621 3990 5358] of the University of Science and Technology of China]

[Text] A solid composite propellant can be thought of as a sponge filled with oxidizers. The sponge consists of a binder and aluminum powder, and is distributed to every size grade of oxidizer in terms of the oxidizer's surface area fraction. Every oxidizer and the binder in the sponge around it make up a special binary propellant. From the energy required to ignite the aluminum powder and being offered by the binary propellant, the

size distribution of the aluminum agglomerates that have just left the burning surface can be calculated. The calculated values are in good agreement with the experimental results. This indicates that a reasonable size match between the oxidizers and the aluminum powders is important. This model is useful for guiding solid propellant development, and will provide the base data for predicting the performance of solid motors.

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### Improving Time Suboptimal Control

40090001c Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 40-46

[English abstract of article by Wang Zicai [3769 1311 2088], Zhao Jianhua [6392 1696 5478] and Zhao Zhangan [6392 7022 1344] of Harbin Institute of Technology]

[Text] In this paper, the problem involving time suboptimal control is explored based on References 1 and 2. After studying some of the characteristics of the time suboptimal control, the authors propose a new design method which is very practical for designing the control system and, in addition, it can effectively improve the optimal performance of the time suboptimal control system. Various design methods are compared using an example, and the superiority of the new one is confirmed. An engineering control problem is solved by using the new method, and the effects of the method are shown.

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### Influence of Protuberances of Missile Body on Missile Aerodynamic Characteristics

40090001d Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 47-53

[English abstract of article by Wan Yin [8001 7299] of The First Institute, Ministry of Aeronautics and Astronautics Industry]

[Text] Based on a number of experimental results, this paper summarizes the influences of annular and longitudinal protuberances of the missile body on missile aerodynamic characteristics. The most important influence involves changing the level and direction of the rolling moment, which constitutes a basis for attitude control system design. Therefore, the current article provides the design principle for protuberances, and is of practical significance for missile aerodynamic design.

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### Transition-Induced Normal Force, Its Effects on Slender Sharp Cone Aerodynamics

40090001e Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 54-64

[English abstract of article by Lou Hongtian [2869 3163 3944] of Beijing Institute of Aerodynamics]

[Text] Dynamic tests have confirmed that the transition effects of the boundary layer on the dynamic and static stability of a slender sharp cone are significant and regular. It is believed that there is a transition induced normal force at the transition zone<sup>(1)</sup>.

In order to confirm this transition-induced normal force, some static and dynamic tests were performed. The test results indicate that the transition-induced normal force really exists, has a direction opposite to that of the inviscid flow normal force, and is caused by the asymmetric transition at the leeward and windward sides of the cone.

It is this transition-induced normal force that makes the  $C_{N\alpha}$ - $R_e$  curve have a valley in the middle  $R_e$  number where the transition exists on the surface of the cone. When the transition exists on the after body, the static stability decreases while the dynamic stability increases, however, when the transition occurs forward of the center of gravity, the static stability increases while the dynamic stability decreases. When the transition is downstream of the inviscid flow pressure center, the viscous flow pressure center moves forward from the inviscid flow pressure center, while when the transition is upstream, the viscous pressure center moves backward.

The tests were performed in a supersonic and hypersonic wind tunnel, and the Mach Number was 5. The model was a 10 degree half angle sharp cone.

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**Study of Acute Hypoxic Effect on Human Performance Under Aerospace Conditions**

40090001f Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 65-70

[English abstract of article by Zhang Jingxue [1728 7234 7185], Jia Siguang [6328 0674 0342], et al., of the Institute of Space Medico-Engineering, Beijing]

[Text] Eighty-four young men and laboratory personnel were tested in a decompression chamber at altitudes of 1,500, 2,500, 3,000, 4,000, 5,000 and 6,000 m, for durations of 60 minutes. Each experiment was carried out at a prescribed altitude, with a total of 133 man-time experiments completed. Multiple indexes for performance tests, such as numerical memory, auditory vigilance, and manual tracking skills, were examined. By applying statistical and modeling methods, the results obtained were analyzed. Comprehensive evaluations were carried out by applying fuzzy set theory in the processing of five fundamental performance indexes. Meaningful results of acute hypoxic effects on human performance were obtained. These results can be used as scientific data for application to pilots when undertaking flying missions and to astronauts when performing either intra- or extra-vehicular activities, as well as for planning medical support programs.

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**Synthesis of Silicon Carbide Fiber Using Blend of Polycarbosilane, Hydroxy-Terminated-Polybutadiene As Precursor**

40090001g Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 3, Jul 89 pp 86-90

[English abstract of article by Yang Yiming [2799 0001 2494], Yang Shujin [2799 3219 6855] et al., of the National University of Defense Technology]

[Text] This paper reports synthesizing silicon carbide (SiC) fiber by using a blend of polycarbosilane (PC) and the proper amount of hydroxy-terminated-polybutadiene (HTPB) as the precursor. When the blend is used as a precursor to synthesize the SiC fiber, PC and HTPB will react to form a cross-linked polymer at approximately 260°C. Therefore, the amount of oxygen needed in curing the precursor fiber is less, as is the amount of silicon dioxide in the SiC fiber, while the strength of the SiC fiber is higher. Using the blend of PC and 3 wt percent of HTPB as the precursor, the strength of the SiC fiber will increase by approximately 26 percent.

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# **New Reagent for Screening AIDS Virus**

40081001 Beijing GUANGMING RIBAO  
[GUANGMING DAILY] in Chinese 15 Aug 89 p 2

[Summary] A new reagent for screening HIV (human immunodeficiency virus) antibody has been developed by the Institute of Shanghai Biological Products of the Ministry of Health using the Enzyme Marker method and Immunoblotting techniques. The institute is responsible for producing and researching all blood products. As nearly 36 million milliliters of blood are required for these products each year, the institute has tried to develop its own kits for AIDS screening. The new reagent was proven to be sensitive and specific after screening some 20,000 donors' blood specimens.

# **Cloning and Expressing of *Bacillus thuringiensis* subsp. *galleriae* (H5ab) $\delta$ -Endotoxin Gene**

40081002 Beijing ZHONGGUO KEXUE [SERIES B]  
in Chinese No 7, Jul 89 pp 712-717

[Article by Chen Qi [7115 7496], Fan Yunliu [5400 0061 0362], Biotechnology Research Center, Academy of Agricultural Sciences, Beijing]

[Summary] A positive clone FG2 carrying inserted 8.5 Kb BamHI and Sal I fragments has been obtained for the first time by the Academy of Agricultural Sciences by cloning and expressing *Bacillus thuringiensis* subsp. *galleriae* (H5ab)  $\delta$ -endotoxin gene in *E. coli*. The Western blot analysis indicated that the obtained recombinant expressed 130 KD and 68 KD  $\delta$ -endotoxin protein and was able to react with HD-1  $\delta$ -endotoxin antisera. In China, *B. thuringiensis* subsp. *galleriae* (H5ab) and *B. thuringiensis* kurstaki HD-1 are two major insecticide-producing bacteria for producing Lepidoptera (scaly-winged insects) toxin. Therefore, the cloning and expression of H5ab  $\delta$ -endotoxin gene in *E. coli* provides solid ground for further study of  $\delta$ -endotoxin gene sequence and also provides highly efficient gene sources for insecticidal plant gene engineering research.

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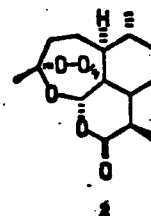
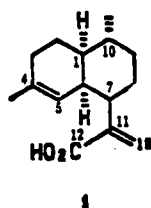
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# **Studies on Structure and Synthesis of Arteannuin and Related Compounds**

40091002 Beijing HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 47 No 7, Jul 89 pp 710-715

[Article by Zhou Weishan [0719 4850 0810] and Huang Dazhong [7806 1129 0022] of the Shanghai Institute of Organic Chemistry, Academia Sinica, Shanghai; Ping Xiefan [1627 1331 0416], et al of the Second Military University]

[Abstract] Naturally, arteannuinic acid and the new anti-malaria drug, arteannuin, coexist in qinghao plant (*Artemisia apiacea* Hance). Arteannuinic acid has been widely used to synthesize arteannuin and the related compounds because of its strong bactericidal activity. This article reports the synthesis of arteannuinic acid using R-(+)-citronellal as a raw material. Schemes of synthesis are shown below:



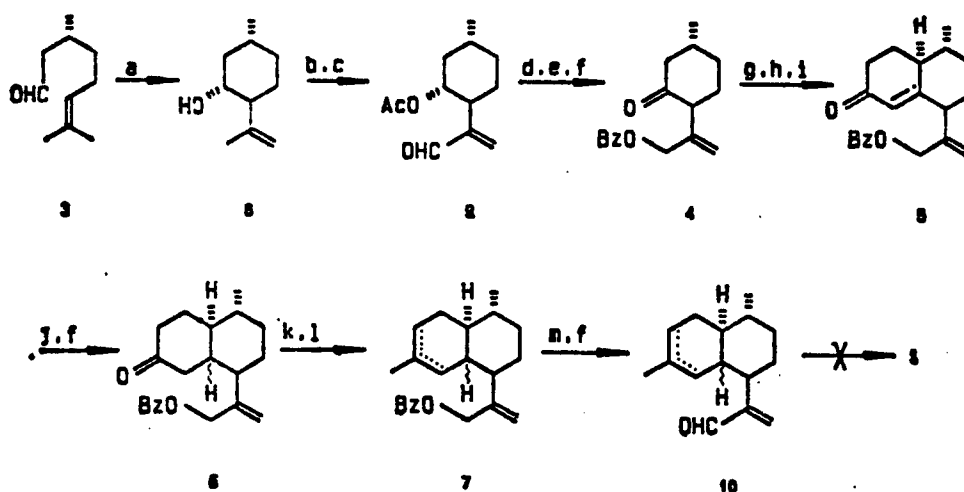


Figure 1

Key: a.  $\text{ZnBr}_2$ ; b.  $\text{Ac}_2\text{O}/\text{Py}$ ; c.  $\text{SeO}_2/\text{EtOH}$ ; d.  $\text{NaBH}_4/\text{MeOH}$ ; e.  $\text{PhCH}_2\text{Cl}/\text{NaH}$ ; f. Jones' Reagent; g.  $\text{CH}_2=\text{CH}(\text{Me}_3\text{Si})\text{COCH}_3, \text{LDA}$ ; h.  $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ ; i.  $(\text{CO}_2\text{H})_2$ ; j.  $\text{NaBH}_4/\text{Py}$ ; k.  $\text{MeMgI}$ ; l.  $p\text{-TsOH}/\text{PhH}$ ; m.  $\text{Na-NH}_3$

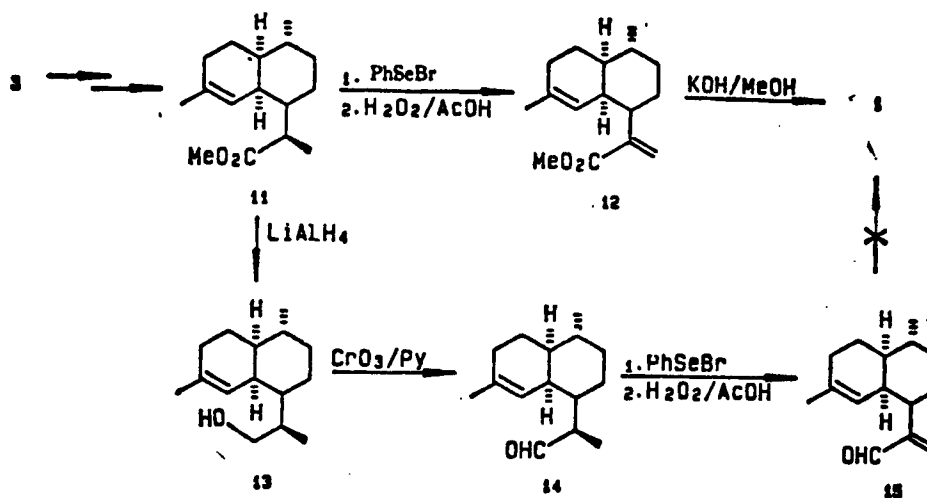
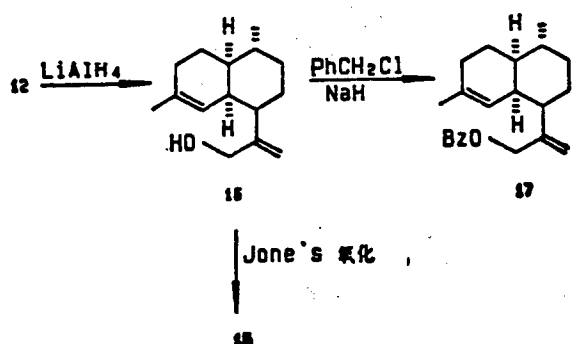


Figure 2

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10. Preparation of the standard control specimen:



**CW Agent First Aid Kit Developed**

40081003a Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 14 Sep 89 p 1

[Summary] An effective new kit—85 hydrocyanic acid first aid injection—has been developed after a 5-year joint research effort by the Third Military University and the Academy of Military Medical Sciences. The injection can be used to treat hydrocyanic acid chemical agent-poisoned soldiers in wartime or to save cyanide-poisoned patients in cyanide-producing factories. In the meanwhile, an effective oral tablet—85-anticyanide—has been developed by the Sixth Institute of the Academy of Military Medical Sciences.

**The Transgenic Fish Expressing Human Growth Hormone Bred**

40081003b Beijing GUANGMING RIBAO [GUANGMING DAILY] in Chinese 29 Aug 89 p 1

[Summary] The CAS Zoology Institute and Beijing Institute of Aquatic Products have successfully bred several

thousand transgenic fishes using self-developed gene engineering techniques. The research was carried out by inserting a human growth hormone gene into mature spawn using carp sperm as a vector. After testing the hatchlings in the PLA Hospital, the results indicated that 50 percent of these transgenic fishes expressed human growth hormone, and these fishes grew faster than the normal ones. In fact, the growth rate was doubled. By using this simple, effective, self-developed gene transfer technique, many new varieties of fishes may be obtained easily by introducing foreign genes into fish spawn. The new technique not only provides a new method for gene engineering breeding, but also makes gene engineering application in fishery enterprises possible.

**Transferred Rice Plant Carrying Insecticidal Gene Produced**

40081003c Beijing GUANGMING RIBAO [GUANGMING DAILY] in Chinese 29 Aug 89 p 1

[Summary] A rice plant carrying anti-snout moth larva gene has been produced by the Biotechnology Research Center of the Chinese Academy of Agricultural Sciences. The plant was obtained by inserting *Bacillus thuringiensis* -endotoxin gene into rice protoplasts. The insecticidal gene against snout moth larva was first isolated from *Bacillus thuringiensis* and then fused with report gene GUS before inserting into rice protoplasts. The presence of insecticidal gene in rice genome can be analyzed by using DNA molecular hybridization method, and the expression of GUS report gene can be tested by the fluorescence method. The achievement of the Biotechnology Research Center will provide new rice variety for relieving serious damage of rice plants by snout moth larva, which will eventually increase rice production in the future.



## More Reports on, Analyses of Computer Viruses

### Some Network and Other Computer Viruses

40080239 Chongqing JISUANJI KEXUE [COMPUTER SCIENCE] in Chinese No 3, 23 Jun 89 pp 77-78

[Article by Du Weiping [2629 5898 1627], Institute of Surveying and Cartography: "Ignorance of Computer Viruses Will Not Be Tolerated"]

[Text] Abstract: This paper describes the infection mechanism, detection, and protective measures against computer viruses.

#### I. Preface

In early November 1988, a computer worm program brought more than 2,500 computers on the American Internet network to a standstill, and scientific research efforts at many units of the U.S. government, research organizations, and universities suffered enormous damage. Although the United States had established the "Computer Virus Industrial Association" (CVIA) sometime before this event, which had begun to offer guidance in selling anti-virus tools, they could not avoid this occurrence. This both proves that the danger of computer viruses has yet to receive sufficient attention, and also shows that anti-viral methods and tools are as yet imperfect.

While the threat of computer worms on networks is enormous, neither can attacks on individual PCs by viruses be ignored. Microcomputers have become rather commonplace throughout China, so the copying of system software and application software among machines gives opportunities for viruses, which can then spread throughout a wide range. It is imperative that research on computer viruses be carried out in China, and that need is urgent.

#### II. The Mechanisms of Virus Transmission

Viruses infecting computers render computer displays useless, or generate obstructive data or images, and computer files and hard disks can be damaged, bringing the computer itself or a network system to a standstill. The particular function of this kind of virus is to damage the following computer resources: 1) files and data; 2) (take over of) CPU resources.

The fundamental characteristic of computer viruses is to infect other programs. Disk files and executable programs can all be infected. There are two items of significance here: one, the process by which other programs are infected, where the virus code that has been copied is added to the front or back of the infected program, and two, the propagation of the virus program in memory. Computer viruses self-replicate as they execute, filling the memory space and slowing down the rate of CPU execution.

We now present several mechanisms by which computer viruses are transmitted:

1. When running a program having a virus, the virus program reproduces, attaching itself to the beginning of a user's files (or system files).

As soon as a virus program is run, the virus first copies itself to the beginning portion of an executable file that it finds, after which it executes the normal part of the program. If files (programs) are run that have been infected several times, they will that many times infect other executable files (programs).

In the following example, the virus routine portion is represented by Virus-line  $n$ , and the regular routine is represented by Correct-line. A program infected 3 times by a virus could be represented as follows:

Virus-line 1;

Virus-line 2;

Virus-line 3;

Correct-line;

The executing process for the virus-infected program would be:

```

-----
: Virus-line 1 :
-----
      v
-----
: Virus-line 2 :
-----
      v
-----
: Virus-line 3 :
-----
      v
-----
: Correct-line :
-----

```

2. After the virus program has been added to the normal program, the execution of the virus program will occur after the normal program has run. Where the first and second situations differ is where the virus routine has been added before the normal program, for then when a program is run that has been infected a number of times, it will require longer CPU time and the result will not be normal. When the virus routine is added behind the normal program, then when a multiply infected program is run, it will always run the normal program portion, but discovery by the user will be more difficult.

3. Aside from its infecting other executable files, when a virus runs it also reproduces itself, which thoroughly

disrupts execution of the normal program. In this situation, if the virus exceeds the limits of memory needed by the operating system to run (i.e., it damages the memory-limiting mechanism of the operating system), then it will be taking up a great deal of space in both memory and in external storage, and it will seize CPU resources, greatly slowing the rate of CPU operations, until finally the system stops.

For an operating system that has no such access mechanisms as ID recognition and password access controls, the files and data it manages are easily infected by viruses. For such operating systems as Unix, the virus must guess a password before it can infect, or it must damage the access mechanisms.

The various computer-virus transmission mechanisms just described have been proven empirically.

### III. Infection by Viruses Within LANs

Within local area networks, users can share such resources as hard disks, and the consequences of infection by a virus can be fatal to shared hard-disk software.

The virus attacks hard-disk management routines, allowing viruses to infect special files within the system. Although there are passwords stipulated for the use of exclusive systems, there is always the possibility of guessing correctly. What this means is that sole reliance on this preventive measure can lower the anti-virus capacity for hard disks and shared resources.

A tragic consequence lies therein. If a particular user occupies all free space on a hard disk, also monitoring the public and private systems on the hard disk, as soon as either system is released, he will take it over exclusively. In that case, in no time at all there will no longer be sharing of resources on the hard disk. The majority of LANs do not currently check for this kind of system resource.

Even though the access control encryption method can be used within LANs, if a user with special verification runs a program containing a virus after logging into the network, access control will never have taken effect. And the virus program so introduced could be infected.

Because PCs have no internal management functions, as soon as PCs on a LAN run a virus program, the self-replication of the virus program will result in eventual take-over of all RAM, causing loss of control over all resource sharing and communications on the LAN.

### IV. Anti-Virus Testing

If a piece of software has no anti-virus capability, it can easily be infected, in which case it is no longer safe. But this is certainly not the fault of the software authors. If the earliest design specifications contained a loophole for virus infection, undiscovered by the designer, then a "proper" loophole will exist in the software completed by that author, and anti-virus testing can be used to detect the loopholes and dangers of computer virus infection. Anti-virus testing requires that the tester be provided with the software design and programming

files. This means that the software designer should be first to do the anti-virus testing since he best understands the design philosophy and process.

Anti-virus testing can improve the capacity of software to resist viruses, but from the point of the system, absolute virus resistance is impossible because it is possible that other anti-virus testing will have been omitted.

### V. Virus Protection and Existing Problems

Because viruses replicate themselves onto either the front or back of normal files during infection of those files, one method is to store these as encrypted files, decrypting them just before execution. If an encrypted file on a disk is infected, that file will not run normally after decryption, which also causes the virus to lose its power to infect.

Another method is to develop software tools that can accurately determine the initial position of a normal program, which would eliminate the purpose of the virus. Research on this area is currently underway.

Inserting software monitoring routines into system software to limit the diffusion of viruses can serve a definite function. But it expends a great deal of system resources itself, which could harm the system and user processes causing damage to the monitored environment.

Due to differences in "varieties" of virus, general purpose virus-checking software cannot be developed, and all that can be done is to develop specific designs. It is for this reason that at the same time as we develop virus testing and monitoring tools we also improve the anti-virus capacities of system software and applications software.

### VI. Conclusions

It has been shown that it is certainly not difficult to generate computer virus programs. And those generated for different kinds of computer environments each have their own characteristics. Programming languages used to write viruses are not limited to assembly language. Because of the excellent assembly-language interfaces provided by many such high-level languages as C, it is possible to use a high-level language to write a virus, which makes it even easier to program viruses. All this requires us to do further studies of computer viruses so that we might take appropriate precautionary measures.

The infection mechanisms for various computer viruses discussed in this paper have been observed under Unix version 7 on a Dual 83/20 and under DOS.

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**Virus Infection Spurs Calls for Copyrights**

40080239 Beijing DIANZI SHICHANG  
[ELECTRONICS MARKET] in Chinese 14 Aug 89 p 1

[Article by Jiang Guozhong [1203 0948 1813] and Xiao Zhong [2556 6988]: "Computer Viruses Have Invaded China; Experts Appeal: We Should Draw Up Copyright Laws as Quickly as Possible and Concentrate on Efforts to Vaccinate and Eliminate Viruses"]

[Text] The fact that computer viruses, already terrorizing computer circles throughout the world, have now invaded China has been proven several times over. Reports indicate that many computers in statistical systems throughout China have become infected, seriously obstructing normal system operation. Experts are warning that we should pay full attention to this phenomenon.

According to reports from the Computing Center of the Bureau of Statistics in Dalian City, all M24 microcomputers at the Center have become infected with a computer virus that is infecting statistical systems throughout China, a virus that can quickly infect IBM PCs and compatibles that use MS-DOS [see JPRS-CST-89-014, 18 Jul 89, pp 46-47].

Although programs and data on either floppy or hard disks in computers infected with this virus have not been damaged, when running normal data processing, many small bouncing balls will frequently appear on the screen. This can only be stopped by resetting the system or by turning it off, which then adversely affects normal operation of the computer. The Computing Center of the Dalian Bureau of Statistics has been plagued by this "virus" for nearly half a year.

This virus is quite contagious, and as soon as an uninfected floppy disk is placed in an infected computer there is the possibility of infection, which disk goes on to be the medium for reckless propagation. During the 1988 statistical-year reporting period, all the districts and counties of Dalian became infected with this computer virus because of annual report programs written or copied on "infected" microcomputers at the Computing Center.

Certain experts have pointed out that one reason computer viruses have poured into China is that there is no copyright law, and some units freely copy foreign software, which gives opportunity for invasion to the virus and has now seriously threatened the security of computers and data on our mainland. It is for this reason that we must heighten our awareness, hasten the creation of a copyright law, and rapidly turn our attention to vaccination and virus elimination.

**More on the Bouncing Ball Virus**

40080239 Beijing DIANZI SHICHANG  
[ELECTRONICS MARKET] in Chinese 14 Aug 89 p 4

[Article by Jiang Wangzhong [1203 2489 1813] and Bei Yan [0554 3601]: "A Brief Look at Computer Viruses"]

[Text] The so-called 'computer virus' is a misguided program that can enter a computer through a floppy disk or a telephone line. It can ruin data in memory, bring an entire computer network to a halt, and also be contagious. The virus program was first discovered in the United States some 4 years ago.

Computer viruses are now also being seen in China, where many computers have become infected, especially in the statistical system around the country. So how then do computers become infected, and how can they be eliminated?

**I. How Computers Have Generated Viruses**

First, the computer boot record is modified. The boot record is a comparatively stable part of the DOS operating system, unable to be arbitrarily altered except by modifying its size or position in a system file. Second, there is a bad cluster indicator (bad sectors) in the file allocation table (FAT), which upon closer examination does not refer to physically damaged sectors on a disk, but has been artificially created. Third, the contents of the bad sectors of an infected disk are not those provided by the DOS system, as they are responsible for a small ball rolling from the top of the screen, the contents of the second sector being the boot record supplied by the DOS operating system. Because the infected disk boot sector has been modified, when the FORMAT/S command from an infected MS-DOS system is used to format a floppy, the system does not indicate that the floppy has any bad sectors. But when this disk is used to initialize a system, the system cannot work normally.

The boot record of an infected disk does not contain that provided by the normal DOS system, and therefore its boot process is as follows: the ROM-BIOS initialization subroutine transfers control to the boot routine, where instead of first reading the IO.SYS, MSDOS.SYS, and system files into RAM, it looks for a FF7 bad cluster indicator in the FAT, finds the log for the bad sector cluster in the 2 corresponding sectors of the floppy, then reads in those contents, thereby entering the virus into RAM. After the bad sectors have been read in, the contents of the infected boot record are written to the boot sector of the hard disk, and a bad cluster mark is set up in the hard disk FAT. The boot contents as provided by the microcomputer virus and the DOS operating system are then written into the position indicated by the disk bad-cluster mark. From this point on, when the computer is booted with an infected DOS disk, it can infect a hard disk that had not contained the virus.

**II. Ways to Get Rid of the Computer Virus**

Microcomputer users can eliminate the virus on both hard and floppy disks with the following method.

To exterminate the virus on a hard disk: boot the computer with the infected DOS operating system, which will then infect the hard disk. From the infected floppy, copy a file from the hard-disk root directory or subdirectory, which will further infect the hard disk.

Before disinfecting the hard disk, separately copy the files in the hard-disk root directory into a subdirectory of the hard disk, after which, copy the files you want to back-up from the hard disk subdirectories onto a floppy. When that has been done, you may use the FORMAT C:/S command to reformat the hard disk, which erases the virus on the hard disk.

To exterminate the virus on a floppy disk: first set up a subdirectory on the hard disk, then copy all files from the infected floppy to the hard disk subdirectory with the command A:>COPY \*.\* C:. Then, reformat the infected floppy with an uninfected DOS system (the MS-DOS

operating system provided with the M24 microcomputer, which was the source of the virus), after which you can restore the files from the hard-disk subdirectory to the floppy with the command C:>COPY \*.\* A:. It must be noted that you cannot work from the root directory of the hard disk because this would reinfect the floppy.

Furthermore, greater care should be taken in normal use of floppies and hard disks, and checks must be made of floppies coming from elsewhere before using. If a new virus is discovered, take appropriate measures immediately to prevent the virus from spreading, which will keep the effects of the virus to a minimum.

### Technical Transformation of Machinery Plants Toward Computer Integrated Manufacturing Systems

40080219 Beijing JICHUANG [MACHINE TOOLS] in  
Chinese No 6, Jun 89 pp 8-14

[Article by Li Kaifo [2621 7030 0154] of Beijing Institute of Machine Tools: "Technical Transformation of Machinery Plants Toward CIMS in China"]

#### [Text] Abstract:

This article discusses the concept of and problems associated with CIMS and points out that CIMS is the eventual goal of enterprise reform. It is necessary to lay out a general plan which includes steps to accomplish the goal by taking the actual situation into consideration. The article also introduces the construction of CIM units and several modes to convert present technology into CIMS.

**Key words:** CIMS, Technology Reform, Machine Manufacturing

The new-technology revolution is changing production modes and the industrial structure and leading to another forward leap in productivity. Some Western nations are implementing high-technology plans such as the Eurika plan. Many experts believe that grasping high technology can significantly increase productivity, profoundly change the labor structure and accelerate the process of social development. While the Chinese government is firmly working toward achieving the goal of quadrupling China's gross industrial and agricultural output value by the year 2000, it is also seriously paying attention to the effect of high technology on future economic and social development. The "high-technology research and development outline" was officially implemented in 1987. The outline consists of over a dozen subjects in seven areas such as information, lasers, automation, energy resources and new materials.

The computer integrated manufacturing system (CIMS) is an important subject in automation. Under the guidance of systems science, CIMS involves the use of information technology, which combines computer with communications to transform conventional manufacturing, particularly machinery manufacturing. The author recently visited over a dozen private machinery plants and investigated the relation between CIMS and technical transformation at some machinery manufacturers. This paper expresses some opinions with regard to this issue.

#### I. Some Manufacturers Have a Basis on Which To Explore CIMS Due to Improvement in Manufacturing Level

1. The concept of relying on technical progress has been greatly enhanced and has paid off in practice.

The concept of relying on technical progress to enhance production and using computer and digital control to increase competitiveness has been accepted by most leaders of the industries we visited. The First Automotive Works has the advantage of using computer-assisted control.

Therefore, a CIMS plan has been formulated by the Beijing Institute of Automation of the Chinese Academy of Sciences (CAS) for its Second Engine Plant. In the past 7 years the Zhengzhou Textile Machinery Factory has been able to increase its total output and profits tax by 16 and 18 percent per year, respectively, by adopting a strategy of continuously improving its ability to develop new products in response to market demand based on increasing flexibility in production. Approximately 10 percent of its key parts are cut and machined by an FMS [flexible manufacturing system] with 12 numerically controlled (NC) machine tools [see JPRS-CST-88-020, 28 Sep 88, p 45]. The remaining 90 percent of the parts are manufactured in flexible machine shops which are organized based on automation of the flow of materials and information. Presently, the plant is strengthening its CA (Computer-Aided) systems, such as CAD (Computer-Aided Design), CAPP (Computer-Aided Process Planning) and MRP-II (Manufacturing Resource Planning) and has actively proposed a technical transformation plan aimed at CIMS. At the one-thousand-worker Dalian Hydraulic Equipment Plant, microcomputer-based CAD and CAT (Computer-Assisted Testing) is being used and microcomputer-based computer-aided control is widely used. In addition, 5 CNC [computer numerically controlled] machine tools are routinely being used in production. In recent years, the factory has increased its total output and profits tax more than 30 percent through making technical progress and cooperating with other people.

2. Results of computer-aided technology and NC technology are becoming more obvious.

The businesses I visited have, to various extents, used systems such as CAD, CAPP, CAT and MIS (Management Information System). The First Automotive Works has an IBM-4381 and uses the MIS system of the COPICS software package. The major plants and offices in the area are connected into a network, consisting of nine sub-management systems including manufacturing, finance, materials, sales, quality, facilities, tooling, spare parts, and personnel and labor relations. The amount of capital consumed in the manufacturing of the "Jiefang" [Liberation] automobiles has been reduced from 70 million yuan to approximately 35 million yuan. In addition, the factory used the APT-4SS software to design 43 parts and 61 molds for the CA-150P auto body. In conjunction with NC machine tools, the entire CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) process of finishing a model for the body was accomplished. The Shenyang First Machine-Tool Plant developed an MIS system which consists of four sub-systems capable of balancing its annual production plan with its capacity, planning technical preparations for production, projecting materials requirements and tracking inventory, and planning production schedules. The system was tested at four shops, including No 1 and 5, and 10 warehouses. In the No 5 shop, the labor productivity (hours/man), hourly cost, and scrap rate were raised or lowered by 30, 20, and 20 percent, respectively. In the No 1 shop the equipment downtime and loss have declined by 76 and 95 percent, respectively. It was capable of achieving complete-set assembly at an [acceptance] rate of 99 percent.

Among the plants we visited, some have ordered or are ordering integrated information systems including CAD/CAM, CAPP and MRP-II.

NC machine tools are routinely used in various plants and are becoming more effective. The FMS and the 15 NC machine tools at the Zhengzhou Textile Machinery Factory are running in two shifts to machine all the key parts. For instance, if a large casing is machined at the horizontal machining center, the processing time can be reduced from 3 months to 6 days. The benefit is obvious.

3. Horizontal associations are promoting specialized manufacturing.

Horizontal alliances in the tree structure push us toward specialized parts production. For instance, the Second Engine Plant of the First Automotive Works only manufactures five components, i.e., cylinders, valve covers, rods, camshafts and crankshafts; and the Xinguang Motor Plant only manufactures cylinders and valve covers. The remaining 90 percent of the parts are supplied by other plants either within or outside the group. This allows the engine manufacturer to concentrate on the machining of key components, assembly and testing of engines and product development; this creates favorable conditions for the business' move toward CIMS.

Of course, CIMS is a long-term goal and requires a step-by-step approach over a long period of time to realize the goal. Although in our belief some businesses have the foundation to explore issues relating to CIMS, this does not imply that they can get there right away. As for the

businesses which have never used NC machine tools, it would be premature to even talk about CIMS.

## II. The Basic Concept of CIMS and Practical Problems Associated With the Concept

### 1. Basic Concept of CIMS

Market competition is essentially product competition. CIMS is an ideal model to optimize a business as a whole. Its advantages are seen by its ability to produce high-quality, low-cost, easily marketable products to allow a business to survive in the marketplace.

CIMS is still not clearly defined. Based on the understanding of the author, CIMS is aimed at a relatively independent manufacturing business entity and the objective is to dynamically optimize this entity (i.e., a combination of high efficiency, high quality, high flexibility and high profitability) using market demand as the input and products to be marketed as the output. It is a closed-loop feedback system linking various segments of the business such as management, manufacturing, and engineering and technology (longitudinally, from market research and management policy decisions to sales; horizontally, from incoming raw materials and semi-finished products to shipping). Under the guidance of systems engineering, it is achieved through means such as flexible manufacturing, computer and communications technology on the basis of simplification, standardization and automation.

Figure 1 shows a schematic diagram of the CIMS concept proposed by Spur et al. in the FRG.

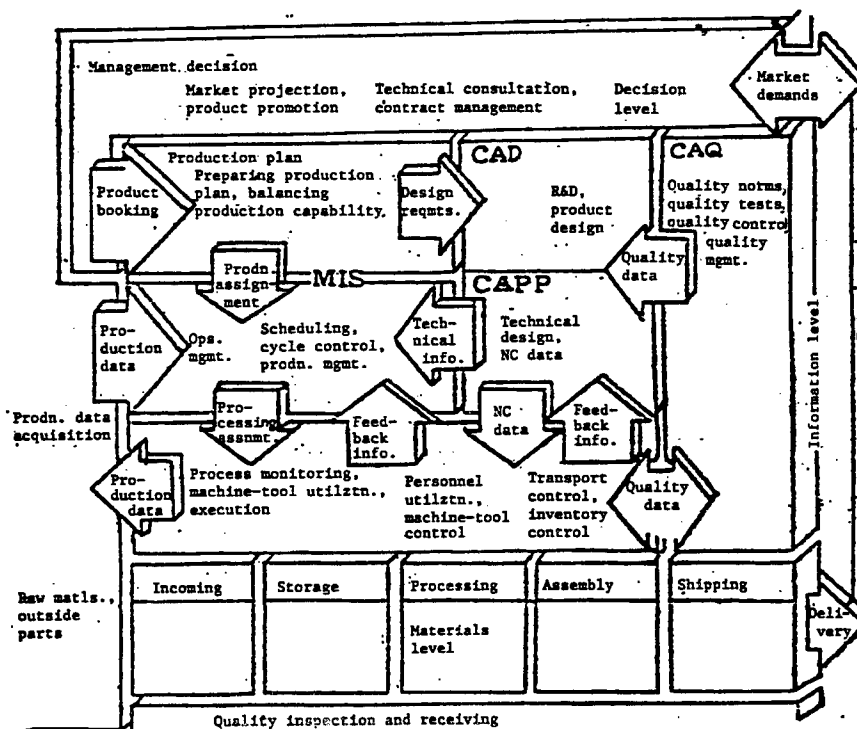


Figure 1. Schematic Diagram of CIMS (CAQ = computer-aided quality control)

From the figure, the overall structure of CIMS consists of three levels:

(1) Decision level: Its main assignment is to study external environments such as the market in order to assist the top management in making the correct decision. This level is composed of the Decision Support System (or DSS).

(2) Information level: Its primary function is to create engineering and technical information (including engineering information systems such as CAD/CAM, CAQ and CAPP), as well as to provide integrated information management for the business (i.e., an MIS).

(3) Materials level: It involves materials associated with production down to the lowest level, including stocking, processing, assembly, testing, warehousing and shipping. Robots, NC machine tools, automated warehouses, automated carts, FMC's (Flexible Machining Cells), FMS's, and FTL's (Flexible Transfer Lines) are the basic equipment and sub-systems.

Integrated technology is system technology, including system structure, system analysis, system simulation and design methods. Integration reduces boundaries and eliminates duplicated information. It breaks down barriers between departments and accelerates the flow of materials and information. It ensures the overall bearing in terms of time and space and promotes the reform of manufacturing technique, production organization and management to allow the business to operate in a new mode. Therefore, CIMS is definitely not an assortment of a number of advanced technologies.

The "binder" for integration is data. Therefore, we must collect, process, store and exchange information. CIMS must ensure the timeliness, correctness, completeness and consistency of the data and the sharing of the data for real-time control and decisionmaking in order to achieve dynamic optimization of the entire entity. Hence, it is necessary to integrate the three levels, i.e., decision, information and materials, through means such as local-area network (LAN) communications and distributed data bases. The MAP (Manufacturing Automation Protocol) network introduced by GM in the United States is such an industrial LAN which meets the CIMS integration requirements.

## 2. Problems Associated With the Concept

The CIMS concept touches on a number of ideas such as simplification, standardization, organization, modularization, automation, distribution and integration, and intellectualization. We do not intend to discuss the theory. Instead, we want to discuss several problems encountered by the machinery plants we visited during technical transformation using CIMS.

(1) CIMS is an open system and it is limited by its environment, especially the market mechanism and technical standards. When a machinery manufacturer uses the CIMS concept to guide its long-range technical

transformation, in addition to following the basic CIMS concept, it should also be consistent with characteristics unique to China and to the plant environment. We must not copy a model (especially a foreign model) and should be realistic.

(2) The CIMS space must include the marketplace, even the worldwide market. An integrated automation without the market is not a true CIMS. The more competitive the marketplace is, the more apparent the superiority of CIMS becomes. It is more urgent that businesses dealing with outside customers or specializing in exports adopt the CIMS concept.

(3) In addition to machinery manufacturers producing a large number of products in small or medium quantities, CIMS is also suitable for manufacturers with medium variety and medium throughput (such as the electrical machinery industry) and low variety and large throughput (such as the automobile industry). There is little technical difficulty for the latter two industries to realize CIMS. Their financial strength and technical foundation are often better. Therefore, the CIMS concept can be used to guide the technical transformation of these businesses.

(4) CIMS can be used to guide the technical transformation of the entire business. Or, we can start with a specific plant to make the breakthrough and then gradually expand to other areas. The latter approach is more appropriate for machinery manufacturers of medium or high throughput where plants or workshops are divided by products.

(5) Specialization in techniques and components is the basis of organization in CIMS. Most people believe the scope of horizontal integration on the bottom level should not be too large. The present focus is on the machining of major components, including the assembly and testing of products.

(6) Simplification must begin with simplifying the products. Not only must we simplify the structure, but also the dimensions. We have to actively promote modular design and implement technical principles to identify, develop and utilize similar information.

(7) When using CIMS to guide the technical transformation of a factory, pieces of manufacturing equipment and computers are purchased over a certain time period. It is not possible to buy from the same manufacturer and to have the same model. We must have a common communications protocol and standard interface to integrate them. In terms of materials flow, the size of the moving tray and the height of the working surface of the machine tool must also be standardized. Hence, there is no CIMS without standardization.

(8) It is not possible to copy the fully automated model from other countries when we use the CIMS concept to guide technical transformation in China. Since integration relies on data flow to accomplish the contact between the decisionmaking level and organization level

and between various links [in the production chain], it is obvious that the automation of information flow has top priority. In the technical transformation plan, under the premise of improving the automation of information flow, we should reduce the degree of automation for materials flow in order to leave room for its automation in the future.

### III. Actively and Steadily Using the CIMS Concept To Guide Technical Transformation by Taking Into Consideration the Special Situation of the Nation and the Plant

1. The machinery industry in China must stress quality and adopt a tower-shaped technical structure.

From a macroscopic perspective, relative to basic industries, the machinery manufacturing industry is more heavily weighted. In the 1960's and 1970's, production capacity was increased by adding people and equipment of the same level. There was almost no increase in labor productivity. The amount of increase in the Sixth 5-Year Plan was also insignificant. The labor productivity, in terms of U.S. dollars, is only 1/30-1/40 of that of Japan or the United States.

The quality of the products produced by the machinery industry in China is not steady (the acceptance rate by random check is less than 70 percent), the cash-flow cycle is long (approximately 1/2 slower than that of Japan or the United States), the product development and delivery cycle is long (almost twice as long as that in Japan, the United States, and the FRG), and the equipment utilization rate is low (less than 30 percent). These problems still exist and have not changed much. Specifically, electrical machinery products made in China are not competitive in the world market (1 percent of worldwide electrical machinery export value in 1988) and the profit margin is poor (the cost of energy and materials to produce 10,000 yuan worth of products is 6-8 times that in Japan and the United States). To solve these problems, it is necessary to carry out reform further, especially reform of the market mechanism. In addition, we must stick to the policy of limiting quantity, improving quality, and insisting on relying on technical progress to raise the quality of existing businesses.

China ranks 127 in its gross national product per capita. However, its gross industrial-agricultural output value is among the first five in the world. Although we are still using horse-drawn carriages in rural areas, we are nonetheless using our own booster rockets to launch geosynchronous satellites. The overall industrial level is not high. Nevertheless, we have some highly technical industries such as the Baoshan Steel Corporation. It is the same in the machine-building industry: we have a number of key businesses there standing on solid foundations. Obviously, such a multi-layer tower structure is already in existence. In the future, the overall science and technology level will move forward as advanced technology on the top level expands like an umbrella. Although it is premature for the entire machine-building

industry to talk about CIMS, some key businesses nonetheless have the capability to use CIMS to guide them through technical transformation. Of course, we need a variety of industries that are working toward CIMS, rather than a few isolated points without much support.

2. Taking a stepwise approach and striving for efficiency.

CIMS requires substantial capital investment. However, the machine-building industry in general is short of capital. Therefore, we must focus on economic benefits when we employ CIMS to guide the technical transformation. Investment will be made in installments and a quick return is desired. Every step must be effective in order to accumulate more funds for the next step. We have to let development feed development.

The level of flexible automation is not that advanced in China. NC machine tools are the basis of flexible automation. Less than 0.5 percent of the total machine tools in China are NC machine tools. The ratio is 11.3 percent in Japan. In general, flexible automation techniques are gradually developed and used in stages. Experience and talent in this area are accumulated and workers are gradually trained by the industry in practice. It is unrealistic for a business with a poor foundation to plan to make a fast move toward CIMS. We have learned several lessons in this regard.

There are two sides of CIMS development: experimental research and industrial application. In higher-learning institutions, it is feasible to focus on integration of experimental CIMS engineering. However, in order to use CIMS to guide a plant through technical transformation, we must stress that each individual technology must meet certain standards. An integration of a number of undependable individual technologies is like a multi-story building built on sand.

For the machine-building industry, CIMS is a long-term goal. To use the CIMS concept to guide a business through its technical transformation is to plan for the future from a system and long-range perspective. It is expected that the ideal will be combined with reality, the long term with the present, and a part with the whole in order to spend our limited funds on critical items. In view of the status of the machine-building industry, and by taking the developmental trends in microelectronics and computers and their impact on the machine-building industry into consideration, we recommend the following specific approach: "overall planning, stepwise implementation, from low to high, approaching the goal step by step."

3. Selecting proper breakthrough points for individual CIMS technologies.

As discussed earlier, individual technologies must meet certain standards when we use the CIMS concept to guide us through technical transformation. Therefore, it is very important to choose the right breakthrough points for individual technologies. The following is an



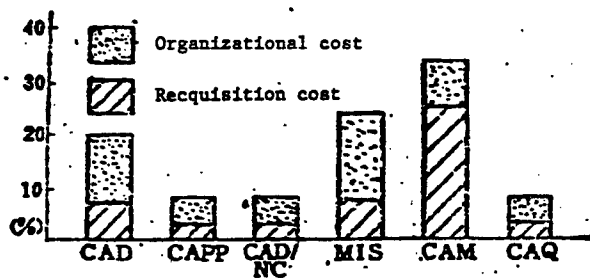


Figure 2. Investment Ratio for Various CIMS Technologies

analysis of the so-called "value index" for each individual technology based on the concept of value engineering. Since there is relatively little data on this area in China, we are borrowing the data from the FRG.

The original definition of the value index is:

$V = \text{functional evaluation index} / \text{cost index}$

Here, it is converted as:

$V = \text{importance index} / \text{investment ratio for individual technology} \times 10$

The upper limit of the importance index in the above equation is the basic importance index and the lower limit is the sum of the basic importance index and the importance index determined by the business condition. For example, the importance index range for CAD (see Figure 3) is 2-4. The investment ratio for an individual CIMS technology can be selected from Figure 2. Since the organizational cost is usually not reflected as a cash expense, only the acquisition cost counts in the investment ratio for each individual technology. The V values of various individual technologies are shown below:

$$V_{CAD} = 2-4 / 0.75 = 2.7-5.3$$

$$V_{CAPP} = 1-2 / 0.35 = 2.9-5.7$$

$$V_{MIS} = 3-5 / 0.8 = 3.8-6.3$$

$$V_{CAM} = 2-3 / 2.5 = 0.8-2$$

$$V_{CAQ} = 1-2 / 0.3 = 3.3-6.7$$

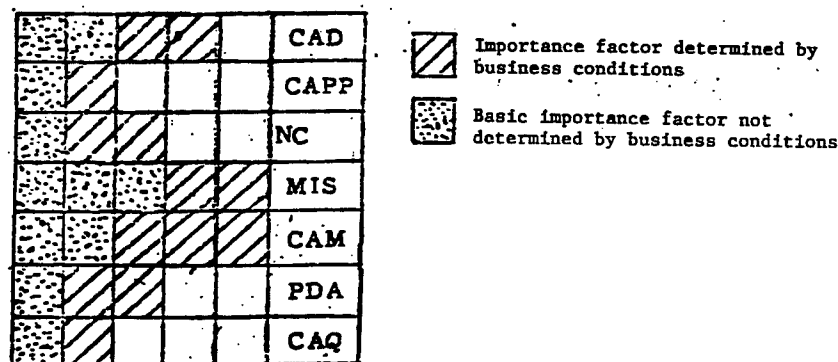


Figure 3. Importance Indices of Various Individual Technologies. PAD is Production Data Acquisition and CAD is Computer-Aided Manufacturing, including various lower-level equipment. (Figures 2 and 3 are found in WERKSTATT UND BETRIEB, No 9, 1987.)

Both theoretical analysis and actual experience have shown the importance of lower-level flexible automated equipment to the machinery industry. However, its value index is not very high. This is because a high degree of equipment automation causes significant cost increases. Integrated electromechanical equipment is higher in cost than similar conventional equipment in China, a situation which will become more serious. The way to raise the CAM value index is to appropriately lower the degree of automation of the lower-level equipment in order to drastically reduce the cost of CAM.

The value indices for MIS (Management Information Systems) and CAQ are relatively high. We should give them priority. CAD and CAPP are more important to small- and medium-volume machinery plants with a variety of products.

Based on what we observed in this visit and the above analysis, we suggest that we start with adopting MIS (including quality management) as well as low-level analytical use of CNC, DNC [direct numerical control], FMC and a little bit of FMS as two breakthrough points for technical transformation guided by CIMS. However, every plant is different and we cannot attempt to apply the same model across the board.

Most of the MIS systems China has imported and developed to date are MRP-II (Manufacturing Resource Planning), which was developed based on MRP-I (Materials Requirements Planning). It expands the principle of purchasing and ordering on demand in MRP-I to the idea of just-in-time (JIT), i.e., manufacturing products in quantity just sufficient to meet the demand. To organize production by demand is not only limited to the supply of raw materials, semi-finished products and purchased components, it also includes the demand for equipment, tooling and labor, as well as the comprehensive management of various activities involving manufacturing, sales, technology, and finance. Therefore, MRP-II is a complete manufacturing-resource plan with overall

information management. Based on statistics collected in the United States, the major effects of MRP-II are that delivery delay, out-of-stock and product re-production decreased by 90, 75 and 50 percent, respectively. In addition, the inventory of parts and semi-finished products, the number of management personnel, and product stock decreased by 30-50, 25, and 20 percent, respectively.

#### **IV. Several Schemes Involving the Use of CIMS To Guide Technical Transformation in Machining**

The lower-level production processes in plants we visited that are undergoing technical transformation under CIMS are focused on machining. Let us not consider the lateral assembly and testing of integrated products and heat treatment. Several schemes regarding machining are discussed below:

##### **1. Large-Variety, Low- and Medium-Volume Production Modes**

Large variety and low- or medium-volume production covers a wide range of industries. For instance, in order to technically transform machining in the machine-tool and textile industries the products must first be simplified and modularized. Based on the principle of group technology, approximately 10 percent of the key components must be sorted out and given priority for machining by CNC, DNC (Direct Numerical Control), FMC and FMS.

For example, the key components in the machine-tool industry include major pieces such as vertical prisms and lathe beds as well as parts such as casings and main shafts.

**Machining of large pieces:** All similar working procedures must be concentrated to minimize the number of times a piece needs to be clamped. The length of the transit route must be shortened to the extent possible. Priority should be given to using NC planer-type milling machines and horizontal machining centers. Since it is difficult to automatically clamp and transport these large parts, they should not be put on-line too early. It is better to use the DNC mode or the individual cell mode.

**Casing machining:** Casing processing is a typical task for a machining center or FMS. An FMS for machining casings can also machine some other prismatic parts.

**Main-shaft machining:** The main shaft is a high-precision and complicated rotating part and it would be appropriate to use either FMS or FMC to machine it. Procedure-wise, we can do turning first, followed by grinding.

As for the remaining 90 percent of the ordinary parts, with the exception of some medium and small prismatic parts that can be machined by the FMS for machining casings, sheet materials should be machined at the sheet-machining center, if possible. Most of the rotating parts

and some prismatic parts can be handled by group-technology-based cells consisting of both NC and conventional machine tools. Each cell must have a computer to receive its MRP-II-allocated assignments from a higher-level computer and to schedule work for the next 1-2 days. In order to raise the utilization rate of machine tools, the parts to be handled by each cell should not be divided too finely (the trend is toward specialization of parts and each plant should let outside vendors supply parts through a horizontal network). In addition, we have to build automated warehouses for materials, especially for medium- and small-size parts.

##### **2. Low-Variety, High-Volume Production Modes**

Motor-vehicle production is a high-volume business. It also requires some flexibility. In particular, bodies of automobiles vary quite a lot. From the standpoint of machining, there is an urgent need to realize flexible automation in the machining of body molds so that it can be connected with CAD and CAM.

An automobile is manufactured in parts at different plants. It takes a long time to change important components such as the engine to a new model. They are produced in a limited number of models at high volume (such as 1.8, 2.2 and 3.5-liter models in a run of 150,000-300,000 units per year). Because the key parts are similar in shape and slightly different in size, we are still primarily using modular machine tools and automatic machines to make them. Some of them are produced on a small number of automated and semi-automated (without automatic transport) lines with high-efficiency NC machine tools. Obviously, the tunable range of a modular machine tool on an automated line is very limited. Especially, it does not have the flexibility to reset. However, in view of the situation in China, it is still a low-investment, high-return scheme. Toyota in Japan built an FMS system specifically for the production of a variety (10-15) of engines at a moderate volume (60,000 units per year). Economically, China is not in a position to adopt such a plan.

Of course, all non-NC equipment should be installed with PLC (Programmable Logic Control) to be connected to the higher-level computer. This allows the computer network to monitor the entire machining process. In addition, we have to strengthen the inspection after each key step in order to achieve closed-loop feedback-compensated quality control. Data on the quality of finished parts are automatically collected and processed by the computer system in order to issue quality-analysis charts and reports.

Since automobile manufacturing is highly specialized, the majority of the parts are purchased from the outside. Therefore, it is necessary to build automated warehouses for parts during machining and assembly in order to minimize mistakes and optimize inventory management to meet assembly requirements.

### 3. Medium-Variety, Medium-(Large)-Volume Production Modes

The so-called medium-variety, medium-volume production mode is primarily aimed at the machining of 4-9 types of parts in a volume of 500-10,000 pieces. In this visit, the products that fell into this domain included medium and small electrical machines, decelerators, and vane pumps. Furthermore, the major components are similar in shape and their sizes vary within a certain range.

It is obvious that it is most appropriate to use an FTL (Flexible Transfer Line) for this kind of production. FMS's may also be used for lower-volume production. The so-called FTL is a processing system with a productivity close to that of an automated line and flexibility lower than that of an FMS. The older generation of FTL's is composed of PLC and CNC machine tools. Usually, they take turns in production. The new-generation FTL consists of regular and special NC machine tools. For instance, the FTL for machining prismatic parts such as casings consists of an in-line machining center (In-line MC), NC machine tools with revolving modular tool bins, and interchangeable-casing NC machine tools. The in-line MC is a fast-feed, short-cycle, three-coordinate single- or multiple-axis, high-efficiency machining center with a small tool magazine and fast tool-change capability. The FTL is in a linear array, with closely spaced machines and materials that are transferred primarily by free rolling; rail-guided carts may also be used.

### 4. Requirements for NC Machine Tools

NC machine tools are the primary equipment at the lower level. The overall requirements include high efficiency, precision, reliability, flexibility and integration. It goes without saying that the requirements for the intrinsic quality of the machine tools, such as reliability, maintenance of precision, dynamic rigidity and thermal distortion, are also very high. Based on the trend of development, there are new functional requirements:

#### (1) Strengthen network communication capability.

One unit not only should be able to communicate with an identical unit but also with other machining units, such as through the MAP interface.

#### (2) Perfect monitoring and self-diagnostic capability.

Control over abnormal situations and monitoring of wear and tear and useful life of tools should be enhanced. The capability to diagnose problems and protect the machine from damage should be perfected. Furthermore, we should develop breakdown-prediction and self-restoration capabilities.

#### (3) Enhance in-line measurement and feedback-control capability.

In-process and post-process measurement and feedback control should be enhanced. In addition, we should

move toward compensating for overall error, instead of compensating for individual mistakes.

#### (4) Strengthen programmable-control capability to coordinate the control of various pieces of peripheral equipment.

#### (5) Increase programmable memory capacity to simplify software writing and improve graphic simulation capability.

#### (6) Further develop artificial intelligence.

The artificial-intelligence expert system not only can be used to determine the flow and optimize the cutting procedure in programming but also can realize real-time optimization in the process. In addition, a man-machine intelligent interface should be installed for voice or natural-language input.

In conclusion, the NC machine tool of the future is a piece of integrated electromechanical equipment with a certain level of intelligence.

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(Edited by Chen Di [7115 6611])

### Key Technical Points of Iron-Making in 1989 Reviewed

40080214 Beijing GANGTIE [IRON AND STEEL] in Chinese Vol 24 No 5, May 89 pp 1-4

[Article by Xu Juliang [1776 4251 5328] of the Science and Technology Office of the Ministry of Metallurgical Industry: "Review of Chinese Iron-Making Techniques in 1988 and Key Points in 1989"]

[Excerpt] [Passage omitted]

### 2. Key Points in 1989

The major problem in iron-making in 1989 is the shortage of coke, which is a long-term problem. Hence, we should focus on conservation of coal for quite some time to come in the future.

#### 2.1 Expanding Use of Blast Furnaces That Burn Powdered Coal

Coal powder can be injected into blast furnace to replace coke and thus alleviate its shortage. This not only reduces the cost of iron-making but also facilitates the operation of the blast furnace. Therefore, it is not only an economical requirement but also a technical need.

#### (1) Utilizing Existing Coal Injection Equipment to Full Capacity

There are 50 blast furnaces using powdered coal in key industries in China. In 1988 the coal injection rate ranged from 30-143 kg/t. Among them, 6 blast furnaces were operating at above 100 kg/t, 38 between 52-82 kg/t, and 6 below 50 kg/t. Forty-four blast furnaces operated

far below capacity. These furnaces should increase their coal injection rate to reach their designed levels. It is estimated that an additional 400,000 tons of coal powder can be injected per year, resulting in a saving of 300,000 tons of coke.

## **(2) Expanding Coal Injection Capacity**

Based on our experience in operating blast furnace with injected powdered coal over the long term in China, when the air temperature is about 1000°C, the coal injection rate can reach 100 kg/t even without using oxygen enriched air. With some oxygen enrichment, it can reach 150 kg/t. Hence, we should target 100-150 kg/t as the goal. Plants below this capacity should be expanded. Blast furnaces that are not equipped with coal injection equipment should immediately add it. Any new blast furnace to be constructed in the future should have a coal power injector built at the same time.

## **(3) Promoting Consumption of Soft Coal**

The majority of blast furnaces use anthracite. However, the amount of anthracite produced in China is limited and it is concentrated in a few areas. On the other hand, soft coal is abundant and widely distributed over China. Its supply is easy to solve. In addition, soft coal contains more volatile substances, burns faster, and has a higher hydrogen content which facilitates reduction processes taking place in the blast furnace. As for safety of injecting soft coal, based on the experience gathered at "Magang" (Maanshan Steel Works) and "Sugang" in China and elsewhere abroad, as long as effective measures with sound scientific basis are taken, safety problems can be resolved.

## **(4) Improving Coal Powder Injection Techniques**

High-temperature air should be used in blast furnaces using injected powdered coal. The average temperature should reach above 1000°C. The iron-making plant should supply all its remaining oxygen to the blast furnace because high air temperature and oxygen enrichment can accelerate the combustion of powdered coal. In order to enhance the replacement ratio, the injection has to be widespread and uniform. To the extent possible, coal ought to be injected at every tuyere. If oxygen is available, we should use pure oxygen nozzles which are more effective than oxygen enriched air nozzles. We must improve the measuring devices and their accuracy. In addition, we have to raise the level of automatic control.

## **(5) Developing Large-Scale, Oxygen-Enriched Coal Injection Methods and New Oxygen-Coal Iron-Making Techniques**

Large-scale, oxygen-enriched coal injection can significantly increase the productivity of the blast furnace, greatly cut back the coke consumption ratio and enrich the coal gas to meet the needs in the development of iron and steel in China. We should organize a systematic study on the effect of oxygen content and coal injection

rate on iron-making and determine the optimal oxygen content and coal injection rate.

## **2.2 Improve Quality of Blast Furnace Raw Materials**

### **(1) Improving Quality of Iron Ore Concentrate**

Approximately 90 percent of the iron is smelted from domestic ores. Most steel-making plants have their own mines. It is not impossible to improve the quality of iron concentrate. Instead, there is considerable potential in this area. Improving the quality of iron ore concentrate is an important task. It is especially critical and urgent since the shortage of coke is limiting the production of iron and steel. In order to improve the quality of iron ore concentrate to reduce deleterious impurities, some smelting plants are rebuilding their ore dressing equipment. We hope to put these projects into production soon. In addition, we should look into the potential of improving concentrate quality in existing ore dressing processes.

### **(2) Mixing Raw Materials in Storage Thoroughly**

A certain amount of raw materials for blast furnaces must be put in reserve and mixed well. Thus, we can minimize any fluctuation, allowing the blast furnace to operate stably. Some plants have built dedicated sites for storing raw materials and have installed mixing equipment in recent years. These facilities should be carefully managed to ensure their full effectiveness. Plants without dedicated mixing equipment should fully utilize existing loading equipment for mixing. With proper control, it will be quite effective. Over the years the quality of agglomerate has been maintained at a stable level at "Shougang" (Capital Steel Works). The iron content fluctuated within 0.5 percent in over 80 percent of the cases. This is primarily accomplished through enhanced mixing of raw materials. "Shougang" would only allow ore concentrates with the correct chemical compositions to directly enter the agglomerate warehouse. The rejects are sent back to the mine for mixing. A specific mixing system was put in place by utilizing existing loading equipment in the mine. Thorough mixing is achieved by rigorous control.

### **(3) Improving the Quality of Agglomerates and Pellets**

Agglomerate is the main raw material for blast furnace in China, approximately 90 percent in key industries and 80 percent in local core industries. Only by raising agglomerate quality can blast furnace achieve high quality, low consumption and high yield. The focus should be placed on further reducing FeO content to enhance reduction activity while maintaining sufficient mechanical strength. The effective method is to increase the thickness of the agglomerate and to sinter at low temperature. In addition, various attempts should be made to maintain its quality, including stabilizing its iron content, alkalinity, FeO content and concentrations of other constituents.

The quality of pellets should also be improved. In order to pair up with the highly alkaline agglomerate, plants usually use acidic pellets. However, the metallurgical properties of the acidic pellet, such as softening and melting temperatures and high temperature reduction, are undesirable. The MgO content in the pellet should be increased to improve its metallurgical properties.

It is extremely critical to sift and remove agglomerate powder. Many plants have installed screening devices in recent years. However, the sifting efficiency in some plants is not high enough to be effective. We should strengthen control and modify equipment to reduce powder content to below 5 percent. The powder content of the agglomerate should be routinely tested as an important parameter in blast furnace operation.

### 2.3 Raising Coke Utilization Rate

Most of the blast furnaces in China are medium and small-scale furnaces. The size of the coke may be quite small. It is all right to reduce the lower limit to 25 mm. For small-scale blast furnaces, it may go even lower. Many plants still have much potential in this aspect. In addition, the coke sieve should be routinely replaced based on its wear and tear to prevent the loss of coke.

Recently, many plants are mixing small coke particles, 10-25 mm in size, with agglomerates to be loaded into blast furnaces. Approximately 10-20 kg is used per ton of iron. This more or less replaces an equivalent amount of large size coke, not only improving ventilation but also increasing coke utilization efficiency. It should be promoted and expanded.

### 2.4 Making Proper Adjustment To Raise Coal Gas Utilization Efficiency

Practical production experience proves that the rational coal gas distribution is to properly develop the flow in the center and suppress the flow along the side. The load along the side is increased depending on quality of the raw materials. When the raw materials are good, it is possible to operate based on a coal gas bell curve. Today, Baoshan Iron and Steel Works and Shougang are following this pattern. Not only the coal gas utilization efficiency is good but also the blast furnace is operating smoothly. It is also good for the protective wall. If the

raw materials are relatively poor, we need to properly develop the flow along the side while maintaining the development of the flow in the center. Otherwise, materials will pile up in the center, coal gas utilization efficiency will deteriorate, coal ratio will rise, and the furnace cannot continue to operate smoothly.

It is necessary to continuously explore ways to improve the distribution of raw materials to improve coal gas utilization efficiency. Jinan Iron Works experimented with mixing coke with ore and obtained significant results. This type of experiments should be carried out at other blast furnaces.

### 2.5 Raising Air Temperature

The average blast furnace air temperature in key industries in 1988 was 988°C with only one-half of the furnaces above 1000°C. The average air temperature in local core industries is 889°C with only three plants at above 1000°C. Based on the capability of existing hot-blast stoves and the calorific value of the coal gas, most blast furnaces can reach 1000°C air temperature. The problem is that some plants are not taking this task seriously. In view of the shortage of coke, it is extremely critical to raise the air temperature. If every blast furnace is raised by 20°C, approximately 200,000 tons of coke can be saved nationwide. The potential is very high.

### 2.6 Reducing Silicon Content in Iron and Steel

Reducing the silicon content in pig iron is desirable in iron and steel making. The blast furnaces at "Shougang," "Hanggang" (Hangzhou Steel Works?), "Magang" and "Wugang" (Wuhan Steel Works) have lowered the silicon content to 0.3-0.5 percent. However, most plants are still above 0.6 percent. Some are as high as 1.0 percent. There is a great potential to save coal by reducing the silicon content. If we can lower the silicon content by 0.1 percent overall, 250,000 tons of coke can be saved nationwide.

Most of the tasks mentioned above can be accomplished without spending any or much money. However, the effects can be significant. Let us hope that all the iron workers can jointly dig into this tremendous potential to move us one more step forward in iron and steel production.

### New Method for Achieving Sub-Micron Line Widths Described

40080242a Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 7, Jul 89 pp 525-528

[Article by Xie Kexun, [6200 0668 8113], Jiang Jianfei [5592, 1696, 7378], and Xie Yin [6200 4964] of the Microelectronics Technology Institute, Shanghai Jiaotong University, revised manuscript received 28 Oct 88: "Method of Fabricating Sub-Micron Spacing"]

#### [Text] Abstract

This is a study on the control of lateral chemical etching in photolithography to obtain line spacing under 0.5 micron.

Key words: sub-micron technology, chemical etching, Josephson junction.

#### I. Introduction

The line width in a semiconductor device has been reduced to the sub-micron level since VLSI (very-large-scale integration) became available. The fabrication of a sub-micron line must depend on electron-beam exposure technology and ion etching. Some semiconductor devices, such as GaAs devices and superconducting Josephson junction devices, only need to have sub-micron lines in certain places. The overall line-spacing requirement is not very demanding. Therefore, some researchers have tried to fabricate sub-micron lines with special techniques using conventional semiconductor equipment. P. C. Chao successfully fabricated a sub-micron gate in a GaAs MESFET [metal semiconductor field-effect transistor], using a cumulative masking method.<sup>[1]</sup> V. J. Kapoor used an edge-etching technique to fabricate sub-micron spacings.<sup>[2]</sup> N. H. Sheng also obtained sub-micron spacing by using a multi-layer masking technique.<sup>[3]</sup> These techniques are useful in fabricating some relatively simple devices. This work employs a lateral etching technique to obtain sub-micron spacing. This method can be used in the study of the semiconductor coupled planar superconducting Josephson junction.<sup>[4]</sup>

#### II. Experimental Method

Lateral etching exists when a photo-lithographic pattern is transferred by wet chemical etching. The depth of etching is approximately the same as that of the layer thickness. Hence, wet etching can only be used in device with line spacing greater than 1 micron. It is possible to achieve sub-micron spacing by lateral etching. Figure 1 shows the experimental procedures we adopted to fabricate sub-micron spacing.

A Si wafer was used as the substrate. A layer of Nb film, approximately 2400 angstroms in thickness, was sputtered on the substrate. The sputtering was done at a pressure of  $5.0 \times 10^{-2}$  Torr, a power of 200 watts, and a

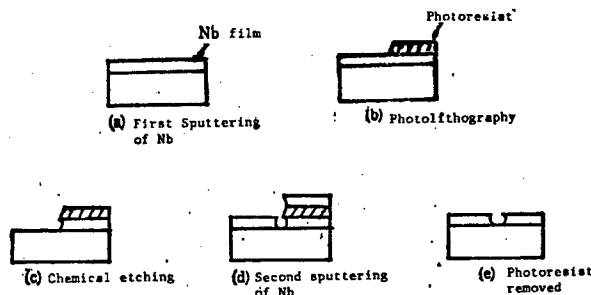


Figure 1. Experimental Principle

Si-wafer temperature of 200°C for 4 minutes. The AZ-1350 photoresist was chosen and its thickness is approximately 1 micron. After photolithography, the Nb film was etched in  $\text{HF}:\text{HNO}_3:\text{HCl} = 14:75:225$  at 20°C. The etching time was controlled so that it stopped a few seconds after the Nb film was just completed dissolved. The photoresist layer was left there when a second Nb layer was deposited. The Si wafer temperature was 100°C, the sputtering was done for 3 minutes and 30 seconds, and the film thickness was approximately 2200 angstroms. Finally, the photoresist was removed with acetone and the experimental result was observed under a scanning electron microscope.

#### III. Experimental Results and Discussion

Figures 2(a) and (b) [not reproduced] are experimental results obtained using the same method. From Figure 2(a) the spacing was measured to be between 0.3 micron and 0.4 micron. However, the spacing is very large in the lower portion due to excessive etching. This is due to improper protection rendered by the photoresist. Figure 2(b) also shows that the spacing is below 0.5 micron. Based on these results, this method could yield line spacing below 0.5 micron.

Experimentally, we found that spacing is primarily determined by the following factors. First is the thickness of the Nb film. This can be explained based on its principle. If the Nb film is thicker, the etching time is correspondingly longer and lateral etching is more severe. In reality, it is difficult to achieve sub-micron spacing when the Nb film thickness reaches 0.5 micron. However, the choice of film thickness is limited by other requirements of the device. Therefore, it is impossible to attain a narrower spacing by further reducing the Nb film thickness. Generally, the Nb electrode must be at least 2000 angstroms thick to have good superconducting characteristics.

The second factor is the control of etching time. The etching rate of the etchant must be moderate. If it is too high, it is impossible to control the process. We used  $\text{HF}:\text{HNO}_3:\text{H}_2\text{O} = 1:3:6$  as the etchant and could not obtain any sub-micron spacing due to lack of control. We then changed to  $\text{HF}:\text{HNO}_3:\text{HCl} = 14:75:225$  which took between 1 and 2 minutes to etch away a 2400-angstrom-thick Nb layer. Because this etchant is

extremely non-corrosive to the Si wafer, it is possible to see whether the Nb film is completely etched away. The extra several seconds is to ensure no residue of Nb is left behind.

The advantages of using this technique to fabricate sub-micron spacing include its simplicity and lack of restriction to the material and method of preparation of the metal layer. We used an evaporated Al layer instead of the sputtered Nb layer and also obtained satisfactory results. The disadvantage is the yield was low and it was difficult to control. Often we found that the last step to remove the photoresist was difficult. The major reason is that the cross-section of the edge of the photoresist was never steep and a Nb film was sputtered on this cross-section because the vacuum was not sufficiently high. Thus, the Nb on the Si wafer was connected to the Nb on the photoresist, as shown in Figure 1(d), which made it impossible to remove the resist. In these experiments very strict requirements were imposed on the photolithographic process and etching-time control. Although the yield is not very high, it is still useful in fabricating simple devices.

#### IV. Conclusions

Through control of lateral etching in chemical etching of a Nb film, sub-micron spacings were obtained using a conventional semiconductor fabrication technique. In principle, there is no limitation on the choice of material and method of film preparation.

The authors wish to thank Ying Zaisheng [2019 0375 3932] of the applied physics department for his assistance in the experimental work.

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#### Electrical Properties of S<sup>+</sup>-Implanted SI GaAs

40080242b Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 7, Jul 89 pp 542-546

[Article by Xia Guanqun [1115 0385 5028], Guan Anmin [7070 1344 3046], Geng Haiyang [5105 3189 7122], and Wang Weiyuan [3769 3262 3293] of the Shanghai Institute of Metallurgy, Chinese Academy of Sciences, manuscript received 19 Mar 88: "Electrical Properties of S<sup>+</sup>-Implanted SI GaAs"]

[Text] Abstract

The electrical properties of S<sup>+</sup>-Implanted SI GaAs after conventional thermal annealing (CTA) and rapid thermal annealing (RTA) are studied. After annealing, the fast diffusion and redistribution of the S<sup>+</sup> implanted into GaAs is not determined by the diffusion of S<sup>+</sup> or the arsenic vacancy V<sub>AS</sub>. Instead, it is determined by enhanced diffusion due to ion implantation. This enhanced diffusion of the S<sup>+</sup> implanted in GaAs can be suppressed by RTA. Thus, the redistribution of S<sup>+</sup> is significantly reduced, resulting in a thin active layer suitable for the fabrication of a GaAs MESFET.

Key words: GaAs, <sup>32</sup>S<sup>+</sup>, ion implantation, rapid thermal annealing, diffusion, redistribution.

#### I. Introduction

A great deal of work has been done abroad on n-type GaAs by ion implantation with S<sup>+</sup>.<sup>[1]</sup> Because of the fast diffusion of S<sup>+</sup> in GaAs, serious longitudinal concentration redistribution takes place during the process of activation in the annealing furnace. Therefore, it is not used as the thin active layer in the GaAs MESFET IC. This redistribution problem has not yet been solved. Several researchers are interested in studying the problem by RTA.

This work is a study of S<sup>+</sup> implantation into intrinsic [i.e., undoped] SI GaAs. The characteristics of the doped material after conventional furnace annealing and infrared graphite rapid annealing are compared, including the effect of factors such as annealing temperature, time and dose of implantation on the activity ratio and concentration redistribution. Finally, the reason for the longitudinal redistribution of S<sup>+</sup> in n-type GaAs is discussed.

#### II. Experimental Method

The substrate is an LEC [liquid encapsulated Czochralski] intrinsic SI GaAs in the direction of <100>. Its resistivity is greater than 10<sup>7</sup> ohm-centimeters. After chemical and mechanical polishing, it was etched in H<sub>2</sub>SO<sub>4</sub>:H<sub>2</sub>O<sub>2</sub>:H<sub>2</sub>O=3:1:1 for 5 minutes at 50°C to remove any damaged layer. The implantation was done on the 600-keV heavy-ion implantation equipment developed by the Institute. <sup>32</sup>S<sup>+</sup> was obtained by electric discharge in CdS vapor. The parameters of implantation were: room temperature, non-channel direction, 600 keV in energy, and 2x10<sup>13</sup> - 8x10<sup>14</sup> cm<sup>-2</sup> in dose. S<sup>+</sup> was activated either by annealing in an unsealed furnace under As pressure<sup>[2]</sup> or by high-frequency infrared graphite rapid annealing.<sup>[3]</sup> Damage recovery and dopant energy level were determined by back scattering and photoluminescence. Carrier concentration distribution, activity and mobility were measured by the electrochemical C-V method and Van der Pauw's method. Specimens for comparison were taken from the same implanted wafer.

### III. Experimental Results

#### 1. Electrical activity and damage recovery of S<sup>+</sup> implantation

Figure 1 shows the dependence of carrier concentration  $N_s$  upon implantation dose  $\phi$  in a thin layer of GaAs implanted with S<sup>+</sup> after 15 minutes of annealing at 900°C. We can see that  $N_s$  begins to be saturated and the activity ratio  $\eta$  starts to fall when  $\phi > 10^{14} \text{ cm}^{-2}$ . In this study the  $\phi$  and  $\eta$  at the point where  $N_s$  is saturated are better than those reported in reference [4].

Table 1 tabulates the mean activity ratio average value of

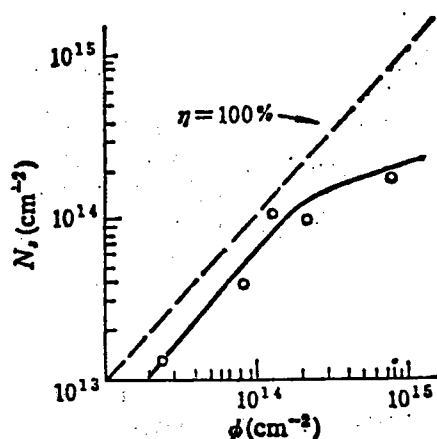


Figure 1. Carrier Concentration Versus Implantation Dose (600 keV, 900°C, 15 min.)

$\eta$  and mean mobility average value of  $\mu$  of RTA and CTA specimens. Based on the data we found that (1) average value of  $\eta$  increased and average value of  $\mu$  first increased and then decreased with temperature in CTA specimens. The optimal condition is 900°C for 15 minutes. (2) In RTA specimens the average value of  $\eta$  is higher than that of the CTA specimens, but the average value of  $\mu$  is comparable to that of the CTA specimens.

Table 1. Comparison of CTA and RTA Specimens

	RTA	CTA				
annealing time t(s)	15	450				
annealing temperature T(°C)	1040	600	700	800	900	1000
activity ratio average value of $\eta$ (%)	70	/	5	17	58	68
mobility average value of $\mu$ ( $\text{cm}^2/\text{V}$ times s)	2800	/	/	2800	2950	1100
implantation conditions	E=600 keV, $\phi=8 \times 10^{13} \text{ cm}^{-2}$					

Figure 2 shows the back-scattering channel-analysis spectra. It not only contains directional spectra of RTA- and CTA-treated S<sup>+</sup>-implanted GaAs specimens but also shows the directional spectrum and random spectrum of

the annealed single-crystal substrate. These results indicate that the damage done to the specimens during ion implantation was essentially eliminated after either 15 seconds of RTA at 1040°C or 15 minutes of CTA at 900°C. The interesting point is that the direction spectrum of the CTA-treated S<sup>+</sup>-implanted specimen is lower than that of the single-crystal substrate. The reason is

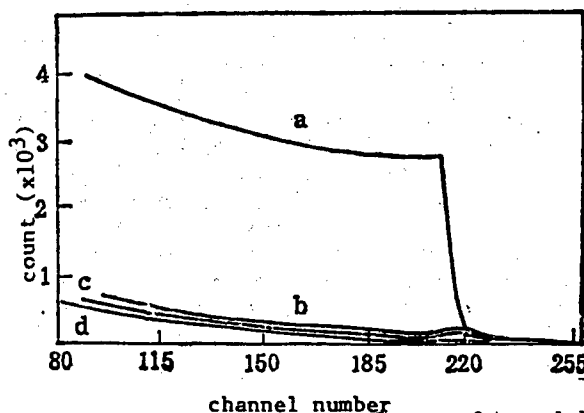


Figure 2. Back-Scattering Energy Spectra of Annealed S<sup>+</sup>-Implanted GaAs (a: random spectrum, b: RTA, c: single-crystal substrate, d: CTA)

still yet to be investigated.

#### 2. Longitudinal Distribution of Carriers N(x)

The effects of annealing temperature T, time t, and implantation dose  $\phi$  on N(x) are studied in depth in this work. A large amount of data was obtained and some results are shown in Figure 3. The results indicate that (1) the optimal CTA condition for S<sup>+</sup> activation is 900°C for 15 minutes. However, the measured N(x) curve significantly deviates from the LSS theoretical values (see Figure 3). (2) At 900°C, both peak concentration and active-layer thickness increase with time t. When annealing time t is constant, they increase with T. However, a P-type layer was found in the substrate of a specimen treated for 15 minutes at 1000°C (see Figure 3). (3) The thickness of the active layer not only depends on the energy of implantation, annealing temperature and time, but also widens significantly with  $\phi$ . (4) The optimal annealing condition for high-frequency infrared graphite RTA is 1040°C for 15 seconds. The measured N(x) curve is very close to the LSS theoretical values and the expansion is relatively small. In addition, the peak concentration is high. It is obviously better than furnace annealing.

#### 3. Photoluminescence Spectra

Figure 4 shows the photoluminescence (PL) spectrum of the S<sup>+</sup>-implanted specimen which was annealed at 900°C for 15 minutes and that of the single-crystal substrate at 77 K. A comparison showed that the S<sup>+</sup>-implanted specimen has two extra strong peaks at 1.234 and 1.408 eV. The 1.234-eV peak has already been reported to be related to S.<sup>[5]</sup> The 1.408-eV peak was observed in



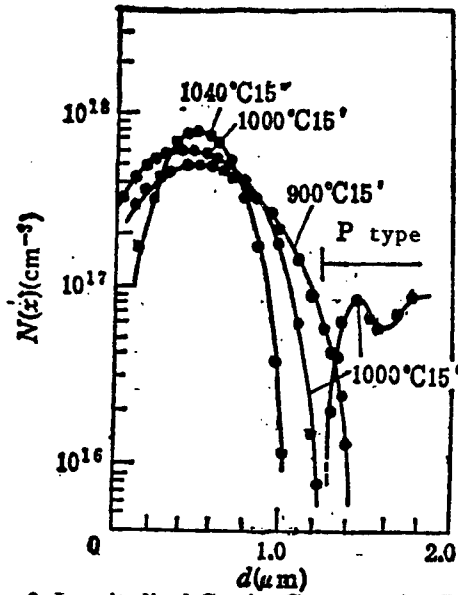


Figure 3. Longitudinal Carrier Concentration Distribution (600 keV,  $8 \times 10^{13} \text{ cm}^{-2}$ )

$\text{Si}^+$ -implanted GaAs specimens. There are a number of interpretations<sup>[6,7,8]</sup> and no conclusion has been reached. The nature of the 1.408-eV peak measured in this work is yet to be investigated.

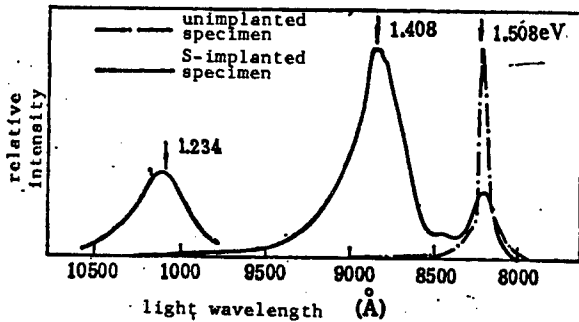


Figure 4. PL Spectra of  $\text{S}^+$ -Implanted GaAs (600 keV,  $8 \times 10^{13} \text{ cm}^{-2}$ )

#### IV. Discussion

The longitudinal diffusion of  $\text{S}^+$  implanted into GaAs in the annealing process can be approximated as the diffusion of a finite source in infinite space; its initial condition is a Gaussian distribution. Reference [9] provides an approximation of the longitudinal concentration distribution after diffusion:

$$N(x, t) = \frac{\eta \cdot \phi}{\sqrt{2\pi\Delta R_p^2 + 4Dt}} \times \exp\left[-\frac{(x - R_p)^2}{2\Delta R_p^2 + 4Dt}\right]$$

where  $N$  is the effective concentration,  $R_p$  is the range projection,  $\Delta R_p$  is the standard deviation,  $x$  is the depth,  $D$  is the diffusion coefficient,  $t$  is the annealing time,  $\eta$  is the electrical activity ratio, and  $\phi$  is the implanted dose.

Using the diffusion coefficient of S at 900°C given in reference [10], i.e.,  $D = 2.64 \times 10^{-14} \text{ cm}^2/\text{s}$ , curve b in Figure 5 was obtained by computation. It is far smaller than the fitted curve c from experimental data ( $D$  was chosen to be  $1.54 \times 10^{-12} \text{ cm}^2/\text{s}$ ). Curve a in Figure 5 is the LSS theoretical value. Reference [11] points out that the fast diffusion of S is determined by the diffusion coefficient of  $V_{\text{As}}$ . However, the  $D$  for the latter is merely  $5.2 \times 10^{-14} \text{ cm}^2/\text{s}$  (calculated based on reference [12]). In order to more precisely verify this point, we conducted annealing experiments at 900°C for 15 minutes in a semi-sealed furnace without arsenic over-pressure and in a sealed furnace under arsenic pressure. The  $N(x)$  distribution curves measured are similar to that obtained in a semi-sealed furnace under arsenic pressure as discussed earlier (figure omitted). The severity of longitudinal concentration redistribution was not improved. This indicates that the concentration and diffusion coefficients  $V_{\text{As}}$  in GaAs are not major factors leading to the fast diffusion of S.

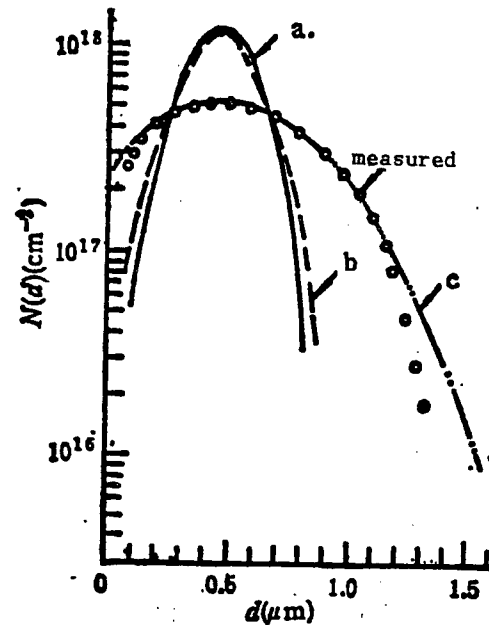


Figure 5. Comparison of Calculated Values to Theoretical Values

The curve fitting of results from RTA at 1040°C for 15 seconds ( $D = 2.0 \times 10^{-12} \text{ cm}^2/\text{s}$ , figure omitted) shows that it is close to the result  $D = 1.23 \times 10^{-12} \text{ cm}^2/\text{s}$  reported in reference [10].

The above calculation shows that conventional thermal diffusion causes very little longitudinal expansion. It cannot explain the longitudinal concentration redistribution of  $\text{S}^+$  in GaAs in the annealing furnace. The concept

proposed in reference [13] that the longitudinal redistribution of the implanted ion is due to enhanced diffusion prior to damage recovery and conventional diffusion after recovery can satisfactorily explain the significant difference in longitudinal concentration between CTA and RTA. Because the CTA temperature is lower, the recovery is slower. At the beginning of the annealing process, the displacement rate is very low. Diffusion primarily happens in the damaged region (enhanced diffusion of the implanted ions). Therefore, the diffusion rate is significantly higher than that for the displacement type of diffusion. A very high temperature is reached during RTA; the damage is instantaneously repaired and  $S^+$  is ready to undergo displacement. Hence, it is more consistent with conventional diffusion. The mechanism for this enhanced diffusion of  $S^+$  during annealing is still yet to be further investigated.

#### V. Conclusions

1. The damage caused by  $S^+$  implantation is essentially eliminated by CTA for 15 minutes at 900°C or by RTA for 15 seconds at 1040°C.
2. The severe  $S^+$  redistribution caused by furnace annealing cannot be explained by conventional thermal diffusion of  $S^+$  or  $V_{As}$ . Enhanced diffusion as a result of ion implantation is the primary cause.
3. The enhanced diffusion of  $S^+$  in GaAs can be suppressed by RTA. The redistribution of  $S^+$  is significantly minimized. It makes it possible to prepare a thin active layer for the fabrication of a GaAs MESFET.

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#### Photoluminescence of Heavily Doped GaAs:Si, GaAs:Be Grown by MBE

40090081a Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 8, Aug 89 pp 607-614]

[English abstract of article by Hu Tiandou [5170 1131 2435], Hu Jizong [6079 4949 1350], et al., of the Institute of Semiconductors, Chinese Academy of Sciences, Beijing]

[Text] The photoluminescence of heavily doped n-GaAs:Si and p-GaAs:Be is measured. The spectral line shapes, peak energy positions and full width at half maximum (FWHM) of heavily doped n- and p-type GaAs are compared in detail. For heavily doped n-GaAs, the main radiative recombination mechanism is that the electrons in the conduction band filled at the higher energy states recombine with holes located at the top of the valence band ( $\delta k$  does not equal 0), which is a non-vertical transition. For heavily doped p-GaAs, the main radiative recombination mechanism is that the electrons near the bottom of the conduction band recombine with the holes near the top of the valence band, which is a vertical transition ( $\delta k = 0$ ).

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**Comparison Between Photoreflectance, Electoreflectance of GaAs-Electrolyte Interface by Means of Direct Observation of Voltage Waveform Across Surface Barrier**

40090081b Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 8, Aug 89 pp 632-636

[English abstract of article by Cao Xiafen [2580 7209 5358], Zhao Dong [6392 0392], et al., of the Department of Physics, Fudan University, Shanghai]

[Text] The properties of the photoreflectance and electoreflectance have been compared intrinsically with each other in the n-GaAs-electrolyte configuration by means of a direct observation of the voltage drops across the surface barrier. A new parameter is introduced to distinguish finely the small differences existing in both spectroscopies. Real distributions of the electric field within the space charge region under the modulation of pulsed laser irradiation or external electric voltage are considered to explain the apparent differences in the two spectroscopies.

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**Investigation of Lattice Mismatch of MBE  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}(001)$  System**

40090081c Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 8, Aug 89 pp 637-640

[English abstract of article by Wang Yutian [3769 3768 3944], Li Chengji [2621 2052 1015], et al., of the Institute of Semiconductors, Chinese Academy of Sciences, Beijing]

[Text] The lattice mismatch of the MBE  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}(001)$  system has been investigated by X-ray double-crystal Diffraction and electron-probe microanalysis methods. The plastic strain critical concentration  $x = 0.114$  is obtained at the epitaxial layer thickness  $t_e$  is approximately equal to 2 microns. When  $x < 0.114$ , there is a linear relationship between the perpendicular strain  $\epsilon$  strain rate and  $x$ . When  $x > 0.114$ , the plastic deformation appears in the epitaxial layer.

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